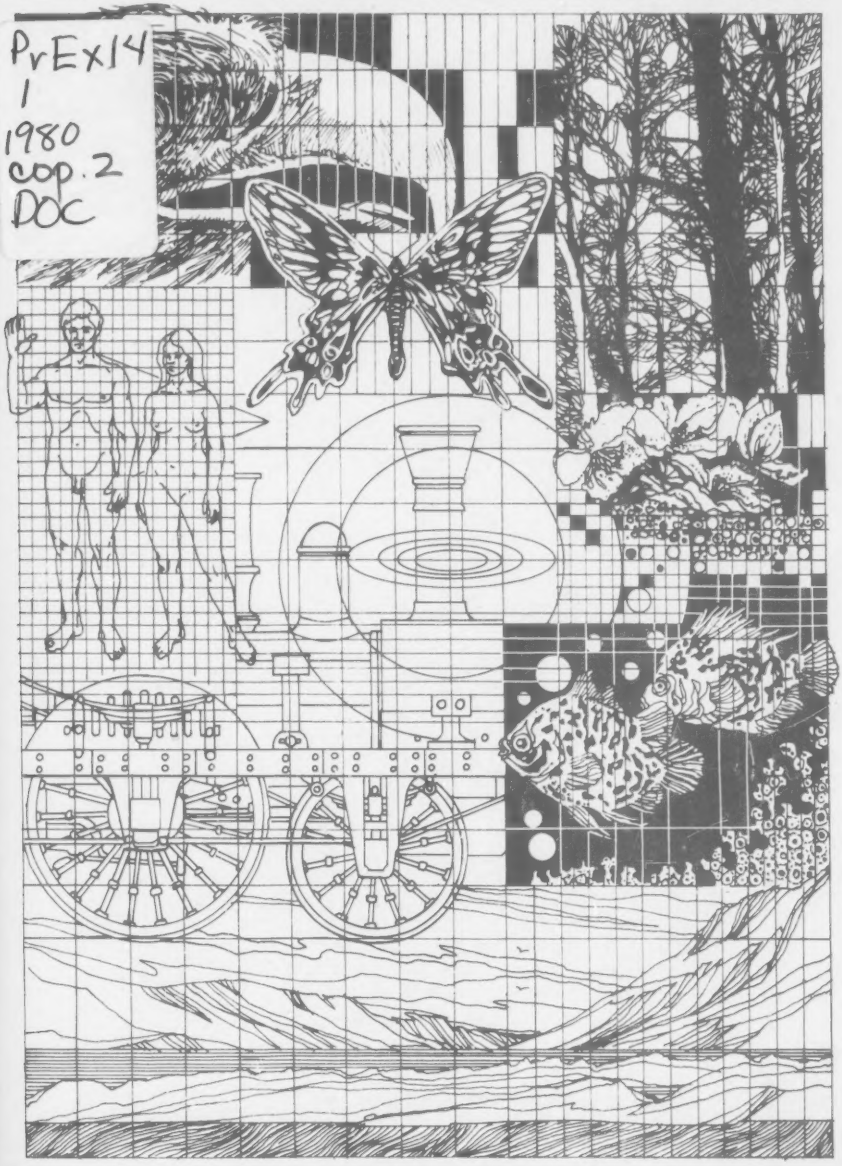
Environmental Quality

the eleventh annual report of the council on environmental quality

PrEx14
1
1980
cop. 2
DOC



Environmental Quality-1980

the
eleventh
annual report
of the
council on
environmental
quality

december 1980

LIBRARIES
MAR 17 1981
COLORADO STATE UNIVERSITY

DATE DUE

CSU MAY 18 1981 CSU

MAY 18 1981

INTERLIBRARY LOAN JUN 9 1981

AT CSU

HIGHSMITH 45-220

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

THE PRESIDENT'S MESSAGE

To the Congress of the United States:

I am pleased to transmit to the Congress the Eleventh Annual Report of the Council on Environmental Quality.

As the Report shows, the nation's environmental programs are producing tangible benefits. In two dozen of our larger cities, the number of days that air quality was in violation of pollution standards declined 18 percent between 1974 and 1978. By and large, water quality in our rivers and lakes has stopped deteriorating. Levels of certain damaging pesticides in the environment have ceased to climb or have dropped, and some of the bird species in danger of extinction a few years ago are returning. The number of American homes using solar power has increased tenfold in just four years. More efficient fuel use by cars and industry has helped to produce an 18 percent decline in oil imports by mid-1980 from 1977 levels.

The signs are unmistakable that we in the United States are learning how to live in balance with nature and beginning to find sustainable ways to exist on this Nation's plentiful but finite resources. Yet there are also undeniable signs that in many other parts of the world the Earth's carrying capacity—the ability of biological systems to meet human needs—is being threatened by human activities. At the time the Declaration of Independence was signed, there were fewer than one billion people on the Earth. Now there are four and one-half billion, and there will be more than six billion by the end of this century. If present trends continue, serious food scarcities are all too probable in many poor nations of the world. The world may continue to lose substantial areas of land to desertlike conditions. In addition, some projections indicate that as much as 40 percent of the world's remaining tropical forests, and perhaps 20 percent of all the species of plants and animals on Earth, could disappear by the year 2000.

We can no longer assume as we could in the past that the Earth will heal and renew itself indefinitely. Human numbers and human works are catching up with the Earth's ability to recover. With care and careful management, our planet's resources—its water, soils,

minerals, forests, fish and air—should be able to sustain us in great numbers. But to a degree unknown in past centuries, humankind is now a potent force on the face of the planet. The quality of human existence in the future will rest on careful stewardship and husbandry of the Earth's resources.

During the 1970s, the government and people of this Nation showed an extraordinary grasp of the ties between human beings and their environment and demonstrated strong leadership in creating a sustainable relationship. The 1980s are presenting new challenges. Our Nation must continue to move forward and extend the progress we have made—progress for which we are being repaid many times over.

JIMMY CARTER.

THE WHITE HOUSE.

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
722 JACKSON PLACE, N. W.
WASHINGTON, D. C. 20006

THE PRESIDENT:

Sir: The Council on Environmental Quality herewith submits its eleventh Annual Environmental Quality Report in accordance with Section 201 of the National Environmental Policy Act of 1969 (42 U.S.C. 4341).

Respectfully,

Gus Speth
Chairman

Jane Yarn
Member

Robert Harris
Member

HIGHLIGHTS

CHAPTER 1 THE GLOBAL ENVIRONMENT

- Signs of a degraded world environment and impoverished resources are evident as the 1980s begin. (p. 1)
- Two major reports of the past year . . . warned of a decline in the earth's carrying capacity that could become progressively worse unless nations act now to change present trends. . . . *The Global 2000 Report to the President* . . . and the *World Conservation Strategy* . . . emphasized the precarious condition of many of the earth's renewable resources: "Living resources essential for human survival and sustainable development are increasingly being destroyed or depleted . . . . The planet's capacity to support people is being irreversibly reduced in both developed and developing countries." (p. 1)
- One of [*Global 2000's*] principal findings is that rapid growth in world population will change little by 2000. . . . In terms of numbers, the population will be growing faster in 2000 than today, adding about 100 million people instead of 75 million each year. More than 90 percent of the growth will take place in poorer, less-developed countries, whose share of the total population will rise from 72 to 79 percent. (p. 2)
- By every measure of material welfare that the study provides—per capita GNP, consumption of food, energy, and minerals—the gulf between rich and poor widens. (pp. 2–3)
- Per capita supplies of other essential resources—fresh water, timber, marine fish—will also decline, and prices will rise. The growing stock of wood per capita is expected to drop almost one-half. . . . The harvest of marine fish . . . will probably not increase. Per capita water supplies will decline one-third because of population growth alone . . . . (p. 3)
- As tropical forests and other habitats disappear, the potential loss of species is unprecedented. Hundreds of thousands of irreplaceable plant and animal species—perhaps as much as 20 percent of all species—could be lost by 2000. (p. 4)
- The study's detailed analysis . . . leads to the overall conclusion that if present trends continue, the result will be worsening poverty and human suffering, resource waste, environmental destruction, and a rising potential for international strife. . . . [H]owever, . . . the study projections were based on the assumption that public policies . . . will remain unchanged through the century. In fact, there is reason for hope. Policies are beginning to change. (pp. 4–5)
- The *World Conservation Strategy* . . . describes stresses on the world environment and resources, pointing out the fact that "hundreds of millions

of rural people in developing countries, including 500 million malnourished and 800 million destitute, are compelled to destroy the resources necessary to free them from starvation and poverty." (p. 5)

- The capacity of the earth to provide enough food for all . . . was examined in detail by the Presidential Commission on World Hunger in a report issued in March 1980. [The *Report* noted that a] crisis of global food supply—even more serious than the current energy crisis—could occur within 20 years . . . [and is] likely unless steps are taken now to increase food production significantly in the developing nations. (p. 7)
- A most serious threat to the biosphere is the rapid disappearance of tropical forests. . . . [E]xtensive cutting of tropical forests is causing loss of agricultural soils, siltation of rivers, and intensified flooding . . . . If present trends continue, tropical deforestation could be responsible for the extinction of as much as 10 percent of the world's plant and animal species by the year 2000. Further, . . . extensive loss of forests might aggravate the rising concentrations of CO_2 in the earth's atmosphere . . . . (pp. 7–8)
- There is a growing realization that the earth's atmosphere could be permanently and disastrously altered by human actions. The burning of fossil fuels . . . [is] causing a steady, measurable buildup of carbon dioxide in the atmosphere that threatens widespread climate change. The burning . . . also leads to the formation of acids in the atmosphere which may fall in rain or snow hundreds of miles from their source. The effects of acid precipitation are not fully understood. They may be damaging forests, crops, and soils seriously. (p. 12)
- Two studies published by the National Academy of Sciences confirm earlier reports that the continued release of [chlorofluorocarbons] will significantly decrease the earth's protective layer of ozone. . . . [A]t 1977 rates, stratospheric ozone concentrations would eventually decline 16.5 percent . . . . As ozone concentrations decrease, the intensity of biologically damaging ultraviolet radiation (DUV) in natural daylight increases. . . . [A] 16 percent ozone depletion would eventually cause several thousand more cases of melanoma per year in the United States, many of them fatal, and several hundred thousand more cases of other skin cancers. (p. 13)
- There seems to be a natural tendency to regard the oceans as a convenient, limitless receptacle for wastes. Experience and understanding are teaching us that, despite their vastness, the oceans' natural capacity to receive, decompose, and recycle wastes has limits. . . . But as problems of waste disposal on land multiply, pressures to use the oceans as a dumping ground become stronger. (p. 15)
- Ocean dumping of the waste materials regulated by EPA dropped from approximately 10.8 million tons in 1973 to 8.7 million tons in 1979 . . . . Dumping of municipal sewage sludge has risen each year as cities treat more sewage in compliance with clean water requirements. Under the Act, dumping of municipal sludge and harmful industrial wastes is to end by 1981 . . . . (p. 16)
- An international plan to control the principal causes of pollution in the Mediterranean Sea was adopted in May 1980. . . . The new agreement . . . concerns pollution originating on land, perhaps 85 percent of the pollutant load entering the Mediterranean. (p. 20)
- The amount of oil spilled from tankers in 1979 was the highest on record. In 1978 there were 35 incidents, and 260,000 metric tons of oil were spilled. In 1979, there were 65 incidents involving 724,000 tons . . . . The Campeche Bay offshore well blowout caused the largest oil spill in history from any source. . . . [It] spilled an estimated 10,000–30,000

barrels per day from June 3, 1979, until March 23, 1980 . . . . The total loss may well exceed 3 million barrels . . . . (pp. 20–21)

- Two important agreements designed to prevent oil pollution from tankers were ratified by the Senate in July 1980. . . . The agreements set stricter international standards for design and operation of oil tankers. (p. 21)
- At its 1980 meeting, the [International Whaling Commission] reduced the quota for all whales to 13,851 and for sperm whales to 1,320 . . . . But proposals for a moratorium on all commercial whaling and on the taking of all sperm whales were defeated. (p. 22)
- U.S. and Canadian officials . . . met several times in 1979 and 1980 on air pollution, particularly on acid precipitation. Canada is concerned about U.S. plans to accelerate the conversion of oil-fired electrical power plants to coal, . . . [and] the United States has been concerned about the effects of a new coal-fired power plant at Coronach, Saskatchewan . . . . (p. 25)
- A report by the U.S.-Canada Research Consultation Group on the long-range transport of air pollutants confirmed the large-scale movement of pollutants both within and between the two countries. . . . The total deposition in the eastern United States and Canada of sulfur in 1979 is estimated at 10 million metric tons, 4.2 million in eastern Canada and 5.8 million in the eastern United States. (p. 25)

CHAPTER 2 ECOLOGY AND NATURAL RESOURCES—BIOLOGICAL DIVERSITY

- [E]xtinction—the death of species—is increasing. . . . Of the 5–10 million species in existence worldwide . . . at least one million are likely to be lost within our lifetimes. (p. 31)
- [B]y reducing biological diversity, humanity is squandering its greatest natural resource, on which we depend for food, oxygen, clean water, energy, building materials, clothes, medicines, psychological well-being, and countless other benefits. (p. 31)
- Genetic diversity . . . maximizes the likelihood that at least some individuals of a species will withstand environmental change. If it is lost—as occurs when humans reduce natural populations to very low levels or excessively inbreed agricultural species—the risk of extinction or crop failure rises markedly. (p. 33)
- [R]are species . . . can[not] be written off without concern. A narrowly or sparsely distributed species may be a keystone species . . . that controls the structure and functioning in its community, or it may possess characteristics valuable to humans . . . . (pp. 33–34)
- In the next 20 years, the human population is expected to swell nearly 50 percent and, in some of the poorest countries, nearly 100 percent. . . . [E]mployment of the earth's reservoir of biological diversity to increase yields and develop new and pest-resistant crops is essential to the billions of humans who need to be fed. (p. 34)
- With the depletion of fossil fuels, organisms that can produce energy-rich materials are increasingly attractive. Many plant species produce hydrocarbon-rich latex, which may be used as fuel . . . . (p. 35)
- [A]lmost one-half the prescriptions in the United States contain ingredients of natural origin. . . . Pharmacologically interesting chemicals are most common in species-rich communities, especially tropical coral reefs and moist forests. (p. 37)

- [I]t is essential to the psychological well-being of . . . many people to collect, hunt, read about, watch, photograph, or be surrounded by diverse living things. (p. 38)

- *Homo sapiens* is not the most numerous species . . . [n]or is . . . [it] the first species to modify its environment. But beavers, woodpeckers, and skunks alter their environments far less than irrigation projects, construction, and air pollution. . . . Yet without intending to do so, the human species is destroying other heirs to the adjusting, perfecting process of evolution because they cannot keep up with the rapidly increasing changes that people cause. (pp. 41–42)

- [E]very house, road, shopping center, commercial building, and parking lot is built on land once occupied by natural communities of organisms. Construction along coastlines and lake shores, on barrier islands, and in river valleys can be particularly damaging to ecologically diverse communities. (p. 43)

- Building roads, canals, railroads, and pipelines . . . [divides] continuous ecosystems into islands. When large ecosystems become smaller . . . the number of species always declines . . . . (p. 44)

- Paradoxically, modern agriculture is both a major beneficiary of and threat to biological diversity. (p. 48)

- In primitive agroecosystems with genetically diverse crop plants . . . yields . . . are dependable, permitting humans to adopt an equilibrial strategy of existence. Industrialized agriculture using genetically uniform varieties . . . may produce poor or no yields at all when unanticipated weather, crop epidemics, or fertilizer shortages occur. . . . [B]y relying on food resources that can fluctuate significantly, humankind has adopted an opportunistic strategy of existence . . . . (pp. 49–51)

- [E]nlightened forest managers can minimize the loss of biological diversity. They can retain the trees along streams . . . clearcut in small patches . . . and use integrated pest management . . . . These measures may decrease short-term profits . . . [but will] provide for sustainable productivity, hence longer-term economic gains. (pp. 53–54)

- Of the world's estimated 5–10 million species, 2–5 million probably occur in tropical moist forests . . . . [Yet] most are totally unknown. (p. 54)

- [T]he discovery of DDT in Antarctic penguins far from possible sources and the DDT-caused decline of brown pelican . . . and peregrine falcon . . . populations increased awareness of the intricacy of the relationship of all living things on this planet. (p. 54)

- Although progress has been made in agriculture, the area affected by chemical pollutants from energy production, transportation, and utilization is increasing. (p. 57)

- Chemical pollution is a [particular] threat to . . . [isolated] island-like habitats . . . and [their] species. (p. 57)

- Although physical and chemical habitat modification is now the most profound threat to ecological diversity, . . . many [species] . . . have declined or disappeared, at least partly because of subsistence, sport, commercial, and pest-control hunting, trapping and fishing, and collecting by hobbyists. (p. 57)

- U.S. sport hunters and fishermen have actively supported government wildlife conservation programs and opposed chemical pollution and unwise land use practices. (p. 57)

- Exotic species can diminish ecological diversity or agricultural productivity by acting as predators, parasites, or competitors . . . . The small Indian mongoose . . . was introduced to Hawaiian and Caribbean islands to control the rats, but it proved much better at controlling native lizards and ground-dwelling birds. (p. 61)
- In May 1977, the President's Executive order on Exotic Organisms directed federal agencies to use their existing authorities to restrict the importation of exotic organisms and their introduction into natural ecosystems. (p. 64)
- [I]n addition to mitigating the damage from development, we can also take positive steps to preserve our biological heritage. There are three main conservation strategies: the gene bank-zoo-botanical garden approach, the species approach, and the ecosystem approach. (p. 64)
- When the loss of species and ecosystems is unavoidable, the gene bank-zoo-botanical garden approach is a lastditch strategy for conserving biological diversity. (p. 65)
- The species approach [concentrates on] wild plants and animals . . . taken primarily for useful parts and products or for sport . . . [It also concentrates on species] which generate special concern and are widely recognized as worth saving from extinction. (p. 66)
- Not all species needing protection are equally likely to receive it . . . [A]lmost 70 percent of the species that have been determined to be endangered or threatened are mammals and birds. . . . [N]o marine plant or invertebrate is on the Endangered Species List. (pp. 66–67)
- [T]he ecosystem approach intentionally preserves diversity . . . [by defining] biologically meaningful, rather than political, . . . boundaries for reserves . . . [to] permit a wide variety of organisms to exist in a quasi-natural balance with minimal human subsidies. (p. 67)
- [M]ost species in well-designed ecological reserves will maintain abundance levels and escape extinction indefinitely . . . so long as they are not . . . polluted, hunted, or harassed severely. . . . [O]nce land is purchased (if purchase is necessary), administering ecological reserves is much less costly than managing species one by one. (p. 69)
- The Endangered Species Act . . . authorizes the Secretaries [of Commerce and Interior] to identify endangered or threatened species, designate habitats critical to their survival, [and] establish and conduct programs for their recovery . . . . [It] directs federal agencies not to carry out, fund, or authorize actions that may jeopardize the existence of or modify the habitats of endangered or threatened species. . . . [T]here has been substantial progress in identifying endangered and threatened species and in establishing programs for their conservation. (pp. 69–70)
- [T]he United States does not have a systematic program for conserving unique and representative ecosystems and their species . . . [which] would help minimize conflicts between development and conservation by ensuring the protection of intact, self-sustaining communities of diverse flora and fauna. (p. 73)

CHAPTER 3 WATER QUALITY

- Ground water has always been thought of as a pristine resource. But recent information reveals the fact that in many locations ground water is contaminated. . . . [T]his contamination . . . includes a variety of materials, most notably toxic organic and inorganic chemicals. . . . [T]hey may be posing unacceptable human health risks. The discoveries of contamination of ground water by synthetic organic chemicals are particularly

disturbing. . . . There are no federal health standards for most of the organic compounds found in drinking water wells. Many of the chemicals are known or suspected carcinogens or mutagens . . . . (pp. 81–82)

- Ground water is a vast natural resource; its volume is estimated at about 50 times the annual flow of surface water. . . . Ground water supplies 25 percent of the fresh water used for all purposes in the country. . . . [A]pproximately 30 trillion gallons of fresh ground water were withdrawn for all uses in 1975 . . . . In the 25 years from 1950 to 1975, the use of fresh ground water increased over 140 percent. (pp. 83–84)
- Ground water is vulnerable to contamination. Although filtration and adsorption cleanse most pollutants from percolating water, soil and rock strata do not eliminate all toxic organic chemicals. . . . The degree of threat to ground water depends on the material underlying the surface site and the particular geologic and hydrologic conditions. (pp. 84–85)
- There may . . . be long delays and distances between the time and place of contamination and detection. . . . Testing and monitoring are costly. (p. 85)
- [M]any compounds once thought safe—especially synthetic organic chemicals—can have serious and substantial health risks, even in concentrations on the order of 10 parts per billion and below. . . . Many of the light molecular weight chlorinated hydrocarbons measured in drinking water are carcinogens. . . . Medical and scientific evidence suggests that these compounds have no safe levels or thresholds of exposure . . . . (p. 86)
- Contamination of ground water from human activities may come from surface impoundments, landfills, agriculture, leaks and spills, land disposal of waste waters, septic tanks, mining, petroleum and natural gas production, underground injection wells, and other sources . . . . (p. 87)
- The Surface Impoundment Assessment, funded by EPA and conducted by the states, identified 25,749 industrial impoundments in a total of 176,647 impoundments. Because of the hazardous nature of much of the wastes placed in industrial impoundments, the states performed detailed assessments of industrial sites. (p. 88)
- A 1978 *Waste Age* survey identified more than 14,000 active municipal landfills; only 35 percent were in compliance with state regulations. . . . There are no estimates of ground water contamination from abandoned . . . sites, but the new EPA regulations . . . require re-examination of all operating facilities, complete with ground water measurements. (p. 89)
- Septic tanks and cesspools rank highest in total volume of waste water discharged directly to ground water and are the most frequently reported sources of fecal, toxic, and other contamination. (p. 89)
- In recent years, many small towns and single families have lost ground water supplies to contamination. (p. 96)
- [T]he quality of surface waters nationally has not changed much in the last 5 years. The fact that the nation's surface water has not deteriorated despite a growing population and an increased gross national product is an accomplishment for control efforts. Although it appears that large-scale degradation of surface waters has been stopped, water quality data indicate that pollution from some conventional and toxic pollutants is still widespread. . . . [C]leaning up the nation's water takes a long time. (p.100)
- There is a real need for systematic collection of water quality data . . . both upstream and downstream of cities where sewage treatment plants are being constructed. Not only would these data be useful to water quality trends, but they would aid EPA, the Congress, and the public in evaluating the $4 billion per year Construction Grants Program and other

pollution control efforts. . . . Although the water quality in rivers and streams . . . seems to have changed little nationwide, it has improved significantly in many local areas during the 1970s. (p. 108)

- Awareness of water quality degradation caused by toxic substances is growing. Several rivers have been seriously affected by toxic pollutants . . . . Pesticides, hydrocarbon products, solvents, acid residues, and heavy metals are among the pollutants. The 1978 State Water Quality Reports to the Congress . . . revealed that 35 of the 37 states reporting had a problem with pollution by toxic substances. . . . [T]he most widely reported toxic substances problem is contamination by heavy metals. . . . Pollution of rivers and streams by pesticides is [also] a serious problem. (p. 109)

- [O]verall, estuarine conditions are not changing radically. . . . In some estuaries, changes have been taking place for the conventional indicators . . . . For nitrates and total nitrogen the changes are in both directions —improvement in some estuaries and degradation in others. Where [biochemical oxygen demand], fecal coliform bacteria, phosphates, and total phosphorus concentrations have changed, they have been improving. . . . Little change is observable among the heavy metals. (pp. 115–16)

- In 1979, . . . a total of 11,300 [community water supply] systems reported one or more [microbiological contaminant] violations during the year. About 60 percent of the failures to comply were in very small systems, serving fewer than 500 people—systems which often lack adequate skilled labor for satisfactory operation. (p. 116)

- There are many problems associated with water quality data and assessment of national conditions and trends—data sparsity, nonrepresentative monitoring sites, limited detection capability for some pollutants, and uncertain data quality. . . . Quality assurance is only beginning to be implemented in water quality monitoring programs. (p. 120)

- The President . . . directed CEQ to establish an interagency task force to review environmental data and monitoring programs and to recommend improvements. . . . The task force found more than 100 water monitoring programs managed by 20 federal agencies which spent approximately $275 million in fiscal year 1978. . . . [It] identified two major problems—coordination and quality assurance. (pp. 120–22)

- Under the Federal Water Pollution Control Act Amendments of 1972, all municipal sewage treatment plants were to achieve secondary treatment . . . by 1977, . . . and they were all to use the "best practicable" waste treatment technology by 1983. (p. 122)

- Existence of a municipal waste water treatment plant does not guarantee cleaner water. (p. 123)

- In the Clean Water Act of 1977, the Congress encouraged innovative and alternative (I/A) technologies for municipal waste water treatment by providing financial incentives for such projects through September 1981. . . . The Clean Water Act authorizes an increase from 75 to 85 percent in EPA's share of construction costs if a proposed municipal treatment plant incorporates approved I/A features. (p. 124)

- The city of Philadelphia has successfully demonstrated an alternative technology in Somerset County—use of sewage sludge to revegetate disturbed land. (p. 126)

- The 1977 Clean Water Act constituted a midcourse correction for EPA's industrial waste pollution control program. It shifted the focus of control efforts away from the conventional to the toxic pollutants. (p. 127)

- Every public or private facility that discharges wastes directly into waters of the United States must have a permit under the Clean Water Act. . . . [N]early 59,000 . . . permits have been issued to municipal (mostly sewage treatment) and nonmunicipal (mostly industrial) dischargers. (pp. 130–31)
- Nonpoint source water pollution is among the most challenging of pollution problems. In contrast to the important progress made during the 70s in controlling industrial point source discharges and in upgrading municipal sewage treatment facilities, progress with nonpoint sources is negligible. (p. 133)
- As travel becomes more costly, lakes—and rivers—near major population centers will provide even more important recreational opportunities. . . . A conservative estimate is that more than 10,000 of some 37,000 publicly owned lakes are in need of pollution reduction or restoration. (p. 136)

CHAPTER 4 AIR QUALITY

- Available data suggest that, overall, the nation's air quality is continuing to improve, although serious problems exist in many areas, including some of the most densely populated. . . . An examination of 23 urban areas . . . shows that in the aggregate, the number of days in violation of the National Ambient Air Quality Standards . . . decreased 18 percent between 1974 and 1978. . . . Monitoring data . . . indicate that the national average annual concentrations of carbon monoxide, sulfur dioxide, and total suspended particulates dropped between 1973 and 1978, but ozone concentrations remained constant. (p. 146)
- Severe air quality problems continue in several major urban areas. New York and Los Angeles had 174 and 206 days, respectively, in 1978 when air pollution readings violated national standards. (p. 146)
- EPA estimates of national manmade emissions from 1970 to 1978 of four criteria pollutants . . . and of volatile organic compounds . . . [show that] [w]ith the exception of nitrogen oxides, estimated total emissions of these pollutants were either constant or decreasing in the 9 years. For particulates, produced mainly by fuel combustion at factories and power plants, estimated annual emissions have dropped significantly. (p. 170)
- In August 1980, EPA proposed that the maximum allowable 1-hour concentration of CO be reduced from 35 to 25 ppm. (p. 172)
- When SO_x and NO_x are emitted, particularly from tall smoke stacks, these gases often rise high into the atmosphere where they can remain for days. . . . The aerosols can then combine with water vapor in the air (in the form of dew, rain, or snow) to form sulfuric acid or nitric acid. (p. 174)
- Tall stacks are not an isolated phenomenon. . . . [A]n estimated 429 stacks taller than 61 meters (200 feet) have been built since 1970, 283 of them by electric utilities. . . . Most of the tallest . . . are in the East North Central and South Atlantic regions. This point is significant because prevailing winds may be carrying emissions of SO_x and NO_x from these regions into New England and Canada, where the emissions may return to earth as acid deposition. (p. 175)
- As of March 1980, there existed about 27,000 "major" stationary sources of air pollution—a major source is one with the potential to emit more than 100 tons per year of any pollutant . . . . [O]f nearly 6,000 major sources in 13 primary industries . . . 90 percent . . . are classified as being in compliance with air pollution emissions limitations. Of the 60 integrated iron and steel facilities, however, only 13 percent (8) are in compliance. (pp. 179–80)

- The 1977 amendments to the Clean Air Act directed the states to prepare revised state implementation plans (SIPs) by July 1, 1979 . . . . States needing until 1987 to meet the CO and O_3 standards were required to institute a motor vehicle inspection and maintenance (I/M) program as a means of controlling emissions of these auto-related pollutants. (p. 183)
- [A]s homeowners, landlords, and commercial and industrial establishments insulate their dwellings and buildings in response to rising energy prices, they may seal in not only warm or cool air but stale and possibly polluted air as well. . . . Indoor pollutants which are of concern include several that are regulated outdoors under the National Ambient Air Quality Standards and others. (p. 184)
- A promising approach to improving indoor air quality is to use controlled mechanical ventilation through an air-to-air heat exchanger. (p. 188)

CHAPTER 5 TOXIC SUBSTANCES AND ENVIRONMENTAL HEALTH

- Chemicals are invaluable to society, and most are believed relatively safe under normal conditions of use. But there are many chemicals whose environmental and health effects are unknown and some that have been proved harmful. (p. 190)
- Cancer is the only major cause of death whose incidence has continued to rise since 1900. Smoking is undoubtedly part of the cause, but there is evidence that other factors, perhaps including increased public exposure to synthetic organic chemicals, may also be contributing. (p. 190)
- Male and female cancer rates combined increased 3 percent from 1960 to 1970. The most recent data, for the 7 years 1969–76, show that per decade, mortality rose 5.6 percent . . . . (p. 193)
- In the minds of most people, cancers are *the* life-threatening disease resulting from exposure to toxic substances in the workplace and the general environment. But other diseases of environmental origin also pose serious health problems. (p. 195)
- A growing body of scientific evidence suggests that environmental exposures to smoking, alcohol, and other chemicals can affect the ability to conceive, . . . the viability of the fetus, . . . and the health of the infant. . . . Controversy has arisen over such problems in the workplace, in particular whether to remove women from workplaces where substances could adversely affect pregnancy. (pp. 199–200)
- Lead, one of the most useful metals in modern industrial society, has long been known to be highly toxic. . . . The questions of whether current levels of exposure [to lead] constitute a serious hazard and, if so, what sources of exposure are most important and/or most amenable to control have engendered considerable controversy. (p. 206)
- Concentrations of lead in the air in the "cleanest" regions of North America are . . . 100–100,000 times higher than the ambient concentrations believed to have existed 10,000 years ago. . . . The major source of public exposure to lead is food. (pp. 208–209)
- In the view of many experts, a serious environmental problem is the effects of lead on small children. A recent study suggests that at an early age even marginally elevated blood-lead levels can have lasting adverse effects. (p. 209)
- Because of continuing uncertainties about the safety of caffeine, the FDA commissioned the Federation of American Societies for Experimental Biology [(FASEB)] to evaluate the safety of caffeine. . . . Th[e] uncertainties

are reflected in the two major conclusions reached in the FASEB study: "While no evidence . . . on caffeine demonstrates a hazard to the public . . . uncertainties exist requiring . . . additional studies. . . . It is inappropriate to include caffeine among the substances generally recognized as safe (GRAS)." (pp. 210–11)

- Diesel-powered light vehicles presently emit about 1 pound of particulates per 1,000 miles driven. This figure is 20–100 times higher than comparable gasoline-powered catalyst-equipped vehicles. (p. 212)
- Some chemically extracted fractions of diesel exhaust particulates have been shown to produce mutations and cancer-like changes in several types of animal and bacterial tests. . . . Exposure to diesel particulates may aggravate chronic bronchitis, emphysema, asthma, and respiratory infections. (pp. 212–13)
- Severe environmental contamination from improper disposal of toxic wastes continues to come to light. . . . EPA has 7,200 waste disposal sites under active investigation. (p. 214)
- [T]he Resource Conservation and Recovery Act requires safe disposal of hazardous wastes. In February and May 1980, EPA issued major regulations implementing [the Act] . . . . The regulations define hazardous wastes and establish a cradle-to-grave management system . . . . (p. 220)
- In December 1979, the Department of Justice and the Environmental Protection Agency filed the largest environmental protection action to date. The suits charged Hooker Chemical Company, its parent company Occidental Petroleum Corporation, and Olin Corporation with violating federal pollution laws and endangering human health and the environment at Love Canal . . . . (pp. 220–21)
- These and 25 other suits filed as of July 1980 are part of a new emphasis on enforcement of hazardous water pollution laws. (p. 221)
- The high cost of proper disposal . . . lack of uniform legal requirements and enforcement, and the shortage of safe disposal sites are probably the major reasons for industry's failure to dispose of wastes properly. (p. 221)
- In December 1980, . . . the Comprehensive Environmental Response, Compensation, and Liability Act became law. This landmark legislation establishes a $1.6 billion fund for cleanup of spills of hazardous substances and for cleanup of inactive hazardous waste disposal sites. (p. 222)
- The issue of compensation for environmentally related diseases has taken on an immediacy as new and disturbing facts have emerged about the effects of some chemicals and substances on human health. (p. 223)
- Identifying and compensating victims is complicated by the characteristics of environmentally caused disease. . . . Compensation for environmental disease has not been considered systematically. State-based tort law, private and government insurance, and social welfare programs provide medical, disability, or other compensation under some circumstances. (pp. 224–26)
- If forced to pay the full costs for use of toxic substances, including health and safety costs, companies may find it profitable to manufacture only those products that the public deems essential. (p. 227)
- [B]usinesses have legitimate interests in keeping some information secret from competitors. . . . [P]rotecting trade secrets from general disclosure severely limits the public's ability to participate in regulatory decisions and to make informed choices about where to work or what products to use. Medical and scientific research is also impaired by data confidentiality. (pp. 230–31)

- The Toxic Substances Strategy Committee (TSSC) considered the trade secret issue . . . and recommended that agencies operating under statutes that do not permit disclosure of . . . data in raw form release detailed summaries of such data. . . . The TSSC also recommended that agencies be given statutory authority to release . . . data in raw form . . . to selected persons or groups who satisfy a "good cause" public interest standard. (p. 232)
- Encouragement of more, better, and earlier testing of chemicals for possible adverse effects on human health and the environment was a driving force behind passage of the Toxic Substances Control Act [TSCA] of 1976. Yet 4 years later, it is the complex testing issues that are a significant obstacle to timely implementation of the Act. (pp. 233–34)
- EPA's early experience with TSCA's premanufacture review process, which went into effect in July 1979, indicates that industry is not providing sufficient data for determining risk. (pp. 233–34)
- EPA efforts to develop policies for issuing test rules have been controversial. Disagreement has centered on how chemicals are selected for testing, how detailed an evaluation must precede issuance of a test rule, and what kinds of tests should be conducted by whom. (p. 236)
- In 1977, the sale of more than 2 million pairs of TRIS-treated children's pajamas abroad focused U.S. and international attention on the problem of "dumping" stringently regulated U.S. Products abroad. . . . An Ad Hoc Working Group consisting of 24 federal agencies was convened to consider federal policy on export of hazardous substances. . . . As of July 1980, the Working Group was seeking additional public comment on and was refining its proposals. (pp. 240–42)

CHAPTER 6 ENERGY

- The past year has been one of significant progress on long-term energy problems. Perhaps the most notable gains were in energy efficiency, largely the result of Administration policies to decontrol oil and gas prices. (p. 251)
- Total domestic energy consumption in 1979 rose only modestly from its 1978 level. This fact appears to be largely the result of the energy system's overall response to rapidly changing economic factors. (p. 256)
- Total U.S. energy consumption in 1979 is estimated at 78.8 QBtu, an increase of approximately 0.8 percent over the 1978 level of 78.2 . . . . This small percentage increase is markedly lower than the 3-year (1976–78) annual growth rates of 2–5 percent. (p. 258)
- The continuing heavy dependence of the United States on unreliable foreign sources of oil remains one of the most serious economic and national security problems. . . . [T]he President proposed three major legislative initiatives during 1979 to reduce foreign oil imports in the 1980s—creation of an Energy Mobilization Board, creation of an Energy Security Corporation . . . and establishment of a windfall profits tax. (p. 262)
- [O]n June 30, 1980, the President signed the Energy Security Act . . . [which will] stimulate the production of 2 million barrels per day of synthetic fuels by 1992, [establish] a Solar Energy and Conservation Bank, [and provide for] biomass financial assistance programs . . . . (p. 264)
- In the past year the CO_2 problem and its possible adverse climate effects have drawn increased attention from scientists and policymakers because the concentration of carbon dioxide in the earth's atmosphere is steadily rising. (p. 265)

- It is estimated that a doubling of the atmospheric CO_2 concentration could raise average global surface temperatures about 3° C (5.4° F) and increase the winter average in the north polar region as much as 7°–10° C. There are significant uncertainties in the prediction of climatic and socioeconomic effects of such a global warming. Possible climatic effects include change in wind direction and speed, in ocean currents, and in precipitation patterns. If these large-scale climatic changes occurred, the socioeconomic impacts would be significant. (pp. 265–66)
- Fuels derived from biomass . . . are attractive because they are both renewable and storable. (p. 267)
- Intensive biomass farming and residue collection could increase the already significant environmental problems of water availability, pollution, and topsoil loss. . . . The substantial land and water requirements for terrestrial biomass energy production could compete with requirements for food and fiber production in some regions. (p. 268)
- [S]o long as fossil energy remains available at reasonable costs, hydrocarbon fuels and electricity will compete for primacy as energy carriers. But if high prices, scarcity, or environmental constraints limit the use of fossil energy, hydrogen may well become competitive with electricity for uses that readily lend themselves to gaseous or liquid fuels. (p. 279)
- The outer continental shelf (OCS) of the United States currently supplies about 9 percent of the oil and 23 percent of the gas produced in the United States. Although government and industry estimate that 60 percent of the nation's undiscovered oil and natural gas resources may be located in the OCS, exploration in many areas so far has been disappointing. (p. 279)
- In March 1980, the Secretary of Interior submitted to the President and the Congress the proposed final oil and gas leasing program for the OCS. . . . The leasing schedule covers the 5-year period from June 1980 to May 1985 . . . [and] calls for 36 lease sales . . . . (p. 280)
- The leasing schedule is designed to allow sufficient time for Interior to carry out careful environmental analysis and planning and to consult extensively with affected interests before final decisions on individual sales are made. (p. 280)
- It is now expected that Interior will lease federal lands containing up to 1.5 billion tons of coal between 1981 and 1982. Several regions have been identified as possible candidates for leasing. (p. 283)
- The March 1979 accident at the Three Mile Island (TMI) nuclear power plant brought the nation dangerously close to a major health disaster. President Carter immediately established a 12-member commission to review the accident and to make recommendations to him. . . . The commission's final report . . . was highly critical of both the nuclear industry and the federal regulatory program designed to police it. . . . The commission also concluded that in spite of serious damage to the power plant, the radioactive releases from the accident have a "negligible effect on the physical health of individuals." (p. 287)
- On February 12, 1980, culminating nearly 2 years of technical and policy review, President Carter announced the nation's first comprehensive radioactive waste management program. The paramount objective of the policy is to protect the health and safety of all. (p. 288)
- The final plenary conference of the International Nuclear Fuel Cycle Evaluation (INFCE) was held February 25–29, 1980, in Vienna. . . . Although the INFCE neither endorsed nor rejected U.S. concerns with reprocessing and breeder reactors, it recognized the possible proliferation risks of reprocessing and other fuel cycle activities. (pp. 289–90)

CHAPTER 7 NATURAL RESOURCES

- Conflicts among . . . competing uses of the nation's natural resources intensified during the last decade as people began to recognize both the economic and environmental limits of resource exploitation. . . . [A] common understanding is emerging from this competition—the need for long-term conservation and management . . . . (p. 294)
- Concern with federal land management policies has existed since the 19th century. . . . [B]ut many of the same questions remain—how much land the federal government should retain, for what purposes lands should be managed, and who should decide the priorities . . . . (p. 295)
- The last decade has witnessed the beginning of a new era for public lands, with formalization of long-term multiple-use management through legislation. (p. 297)
- Considered by President Carter as the most important conservation issue of his Administration, the protection and management of [the Alaska public] lands became the focus of extended debate in the Congress. (p. 299)
- In late 1980 the Congress passed and the President signed the Senate version of the Alaska lands bill. It supersedes and generally incorporates the prior Executive actions taken by the Administration (p. 300)
- Crowding and traffic congestion are a serious problem in some of the more popular parks. The National Park Service proposed a management plan for Yosemite National Park in California again in 1980, the fourth time in 12 years. (p. 300)
- [T]he Secretary of Agriculture issued land and resource management planning regulations in 1979. They include specific directions on how the Forest Service should prepare management plans at the Forest and regional levels. (p. 303)
- [T]he Administration recommended that 15.4 million additional acres of National Forest System lands (8 percent of the System) be protected as Wilderness. The Administration also recommended further study of 10.8 million roadless acres . . . . (p. 305)
- Lake Tahoe, situated in the Sierra Nevada Mountains on the border of California and Nevada, is one of the deepest and clearest large alpine lakes in the world. . . . In October, the President issued an Executive order to ensure that no federal action is taken that would lead to further environmental deterioration. (p. 307)
- The President's 1979 Environmental Message included policy initiatives to achieve the goals set out in the [Federal Land Policy and Management Act (FLPMA)]. He directed the Secretary of Interior to develop a comprehensive program development process—similar to the Forest Service RPA procedures—for BLM lands. (p. 307)
- FLPMA . . . directed that public lands managed by BLM be inventoried for wilderness values. By May 30, 1980, inventory of the 174 million acres in the contiguous states had eliminated 124 million acres which were found to lack wilderness characteristics. Approximately 11 million acres were identified as wilderness study areas . . . . (p. 309)
- In November 1979, BLM proposed its new rangeland policy in a draft report, "Managing the Public Rangelands" . . . . (p. 310)
- In the report discussing the findings of the organic farming research project, the USDA states that the production systems used by organic farmers "are also those which have been cited as best management practices

. . . for controlling soil erosion, minimizing water pollution, and conserving energy." (p. 312)

- Erosion nearly always reduces soil productivity . . . [and] increases the cost of producing agricultural commodities. A rule of thumb . . . is that loss of 1 inch of topsoil—150 tons on 1 acre—generally reduces corn yields between 2 and 3 bushels on that acre. (p. 315)
- An important environmental problem associated with energy production from crop residues is that of maintaining soil fertility and preventing excessive soil loss. World nutrition may also be affected if the food needs of the hungry compete with the demand for liquid fuels derived from grain crops. (p. 316)
- [S]everal bills before the Congress call for minimum soil conservation standards . . . as part of a program offering farmers economic incentives to ensure compliance . . . . As pressure on agricultural resources grows, voluntary programs may prove ineffective or too costly . . . . (p. 320)
- Because all farms must control a wide assortment of crop pests, policies furthering the use of [integrated pest management] could have broad benefits for both farm profits and environmental quality. A CEQ report published in late 1979 includes recommendations on . . . IPM strategies. (p. 321)
- [F]ederal policy analysts question why some producers willingly seek out new production systems while others adhere to older, environmentally damaging practices. Invariably, economic return is the key element in a farmer's choice of a management system. (p. 322)
- More than 40 percent of U.S. cropland is farmed under some kind of rental or crop-share agreement . . . [which] presents a serious obstacle to effective conservation policy. (p. 323)
- In the Columbia River Basin a major eruption of Mount St. Helens melted glaciers and produced massive mudflows and unprecedented flooding in the Toutle River. Approximately 25 million cubic yards of mud, trees, and other debris were carried downstream . . . . (p. 324)
- According to a 1980 report by the Water Resources Council, . . . the lack of state legislative and administrative authority limits the states' ability to manage such serious problems as ground water overdraft and pollution, floodplain management, erosion and sedimentation in surface waters, and drainage and dredging of wetlands. (p. 326)
- Bills to authorize many new water resources projects were developed in late 1979 and early 1980. . . . Many of the proposed projects lacked complete planning documents and environmental impact statements and appeared to provide no net economic benefits to the nation. (p. 329)
- Environmental and economic impacts of various mining and reclamation technologies for minerals other than coal were evaluated in a major study released in 1979. (p. 330)
- The United States is currently one of the world's leading suppliers of phosphate rock. If U.S. production is stepped up . . . , environmental problems associated with the mining and processing of phosphates will increase . . . . (p. 331)

CHAPTER 8 HUMAN SETTLEMENTS AND LAND USE

- The 1970s witnessed a slowing of growth for the population as a whole, the continuation of some demographic trends, and some reversals, notably the migration to rural areas throughout the country. (p. 339)

- The total population grew 8.3 percent (17 million people) from 1970 to 1979, compared to 13.3 percent for the previous decade. The population reached 221 million by January 1980, having grown nearly 2 million during the previous year. (p. 339)
- Metropolitan growth is still substantial in the West and Southwest, and rural growth is triple the national rate. [This growth] . . . [has] contributed to the process of land degradation known as desertification . . . , one of the nation's most serious environmental problems. (p. 345)
- Other areas where the population is growing . . . are the coasts. The barrier islands, spits, and beaches—approximately 300 of them along the East and Gulf coasts—are among the least stable natural areas that people use. . . . A 1979 study reported that in 108 barrier island counties, the population had increased by more than 30 percent in the 1960s, well over twice the national growth rate. . . . Approximately 138,000 acres were urbanized over the period, an average of 6,000 acres per year. (p. 345)
- Construction continues in the floodplains along rivers and coasts, despite their vulnerability to floods and frequently their value as agricultural land. (p. 346)
- A Presidential task force estimated annual flood losses at about $1 billion in 1966; 10 years later the U.S. Water Resources Council (WRC) estimated that annual flood losses had more than doubled. . . . If present settlement and property investment trends continue, WRC estimates 1985 losses of $5 billion (1979 dollars). (p. 346)
- The arid West is . . . undergoing rapid environmental change that seriously threatens its long-term productivity and habitability. The change is desertification . . . . (p. 347)
- The overall land area affected by desertification in North America is substantial. It is estimated that 1.1 million square miles, 37 percent of the continent's arid lands, have undergone "severe" desertification. . . . Most of the very severe desertification in North America is in the United States. . . . The United States has already suffered serious economic losses through desertification; future losses of far greater magnitude are possible. (p. 348)
- California's San Joaquin Basin is one of a few areas that has suffered from all the major forces of desertification—poor drainage of irrigated land, overgrazing, cultivation of highly erodible soils, overdraft of ground water, and damage from off-road vehicles. . . . Of the Basin's 4.8 million acres of cultivated cropland, 4.6 million are irrigated. . . . Today about 400,000 acres of irrigated farmland . . . are affected by high brackish water tables. . . . [The] amount of poorly drained land [may] increase to 700,000 acres by the year 2000, and the loss in annual crop yield [may] reach $321.3 million. (pp. 352–53)
- Overgrazing leaves the land susceptible to the erosive force of the wind as well. This fact was demonstrated in December 1977 in the southern San Joaquin. . . . In 24 hours, the wind moved more than 25 million tons of soil in a 373-square-mile rangeland area. (p. 356)
- Urbanization is projected to take over approximately 407,100 acres of prime farmland in the San Joaquin between 1972 and the year 2000. (p. 357)
- The desertification forces . . . have been encouraged both by market factors and—often inadvertently—by federal policy. (p. 357)
- The structure and availability of relief payments have . . . discouraged

strip cropping . . . crop rotation, and the planting of permanent cover on highly erodible land. (p. 358)

- The Federal Great Plains Conservation Program has not yet reached its intended goal, to protect national soil resources by helping farmers to convert erosion-prone cropland into grassland on a cost-share basis. (pp. 358–59)

- Preserving the quality of the nation's soil resources . . . and maintaining the amount of the nation's prime farmland are fundamental resource management goals for the nation. (p. 360)

- U.S. excess productive capacity now accounts for some $31 billion in export trade each year in basic farm commodities. . . . Department of Agriculture projections indicate that the physical limits of productive capacity may be reached by the year 2030. . . . Long before physical limits of productive capacity are reached, however, the economic or environmental costs of producing food may well become dominant factors in determining feasible production levels. (p. 361)

- A recent CEQ study of the land use effects of growth in five rural areas revealed the fact that net population increases are not necessarily the key factor in land use change. (p. 362)

- [T]he direct loss of farmland can be aggravated by significant indirect losses. . . . [F]or each acre lost directly to urban and rural buildup and to transportation uses, at least 1 more acre is isolated by leapfrog development and is lost to agricultural use. (p. 363)

- Whether the rural growth trend will continue as energy costs escalate rapidly is not known. The sharp rise in gasoline costs in the mid-1970s did not, in fact, noticeably affect rural growth. (p. 363)

- Often, by providing needed public services, the government inadvertently creates undesirable settlement patterns and environmental effects. (p. 364)

- The investment tax credit costs the public about $10 billion per year. If it favors expanding communities, which are generally located in the South and West, it may unintentionally exacerbate economic losses in older cities in the Midwest and the Northeast. (p. 365)

- Federal support for transportation, primarily highways, is about $12 billion for construction and $5 billion in related administrative support each year. . . . But federal construction grants have often encouraged . . . [building] without planning for maintenance. As a result, the . . . deteriorating national highway system is in need of further huge investments merely to keep it usable. (pp. 365–66)

CHAPTER 9 NEPA

- The NEPA regulations . . . required that every agency adopt its own procedures by July 30, 1979, tailoring the regulations to its activities and programs. . . . Eighty-nine federal departments, component bureaus, and agencies have published or are scheduled to publish final supplemental NEPA procedures. (p. 370)

- That the regulations are improving decisions, reducing delay, and reducing paperwork was evidenced in an informal Council survey of agency EISs prepared in the first 6 months after the regulations went into effect. . . . Federal agencies have reported savings and economic and environmental benefits from NEPA. (p. 371)

- The Council reviewed the Nuclear Regulatory Commission (NRC) environmental analysis of nuclear power plant accidents and found it seriously deficient. (p. 373)
- The only Supreme Court opinion in the past year to address agency responsibilities under NEPA was *Strycker's Bay Neighborhood Center* v. *Karlen*. (p. 374)
- A significant court decision with nationwide repercussions on Wilderness Area legislation and National Forest planning actions was *California* v. *Bergland* . . . . (p. 376)
- *North Slope Borough* v. *Andrus* related to a federal-state lease sale scheduled for December 1979 in the Beaufort Sea. . . . Opponents claimed that drilling in the extremely harsh conditions of the Beaufort Sea is exceptionally risky for a pristine, fragile, and valuable environment. . . . On July 10, 1980, the Court of Appeals for the District of Columbia issued an order vacating [an earlier] injunction. The following day the Interior Department accepted bids . . . . (pp. 380–81)
- During 1979, citizens, environmental groups, state and local governments, and businesses challenged federal actions under NEPA in 139 lawsuits. (p. 383)
- The most frequent allegation in 1979 NEPA cases, comprising 61 percent of the total number, is that an agency was required to prepare an EIS for a proposed action but failed to do so. (p. 383)
- Approximately 1,400 environmental impact statements . . . were prepared and filed with the Environmental Protection Agency by some 89 federal agencies and component bureaus during 1979. At the same time, thousands of environmental assessments were also prepared by these agencies. (p. 384)

CHAPTER 10 ECONOMICS

- The Council estimates that the nation spent approximately $37 billion in 1979 to comply with federal environmental protection requirements—approximately 1.5 percent of the gross national product. It has been suggested that these expenditures may be slowing the growth of productivity. Although studies on the subject are not conclusive, available data suggest that environmental controls have had little impact on productivity. (p. 387)
- [I]t is essential to recognize that safe workplaces, clean air and water, unspoiled vistas, reclaimed land, and other benefits of environmental regulation are seldom included in estimates of national productivity. . . . [P]ollution abatement measures or other regulation will almost always produce a reduction in *measured* output but an increase in unmeasured benefits. (p. 388)
- Economic incentives may be effective in controlling pollution. . . . The Environmental Protection Agency's bubble and offset policies are attempts to make use of economic incentives within the current regulatory framework. EPA is also considering several other incentive-based approaches. (pp. 389–90)
- [A] means of obtaining more accurate information on the costs of complying with environmental regulation is suggested by recent action taken by the Securities and Exchange Commission. The SEC ordered two very large firms—U.S. Steel and Occidental Petroleum—to disclose to their stockholders potential liabilities arising from pollution control costs or other environmental activities. (p. 392)

- Unsettled issues in the setting of regulations include the extent to which regulatory agencies must demonstrate the benefits of their proposed actions and the relationship that these benefits must bear to the costs of regulation. The Supreme Court considered in part the first of these issues in 1980. (p. 392)
- A study conducted for EPA in 1980 attempted to assess the accuracy of some of the estimated costs of complying with federal environmental law. . . . The study compared . . . estimates of pollution control costs . . . made when a regulation was issued with actual expenditures. . . . Overall, the report shows that EPA appears to be slightly better at estimating compliance costs than are the affected industries. (pp. 396–98)

CONTENTS

	Page
THE PRESIDENT'S MESSAGE	iii
LETTER OF TRANSMITTAL	v
HIGHLIGHTS	vii
Chapter 1 THE GLOBAL ENVIRONMENT	1
World Resources and Environment: Trends and Statistics	2
The Global 2000 Report	2
The World Conservation Strategy	5
World Hunger	7
World Forests	7
The Atmosphere	12
Global Carbon Dioxide Action Plan	12
Atmospheric Ozone Depletion	13
World Climate Impact Studies	15
Oceans	15
Ocean Dumping in U.S. Waters	16
Radioactive Waste Disposal	18
The Mediterranean Protection Agreement	20
Oil Spills	20
International Efforts to Control Oil Pollution	21
Wildlife	22
Whales	22
Caribou Protection	24
The Sea Turtle Conference	24
Bilateral Environmental Efforts	25
Canada	26
Mexico	26
Environmental Planning in Developing Countries	26
Sri Lanka AID Assessment	26
UNEP Caribbean Environmental Action Plan	27
References	27
Chapter 2 ECOLOGY AND LIVING RESOURCES—BIOLOGICAL DIVERSITY	31
Material Benefits of Biological Diversity	32
The Role of Biological Diversity	32
New Sources of Food	34
New Sources of Energy	35
New Sources of Industrial Chemicals and Raw Materials	36
New Sources of Medicines	37

Page

The Psychological and Philosophical Basis for Preserving Biological Diversity ---- 38
Human Reduction of Biological Diversity ---- 40
A New Species and Its Influences ---- 40
Land and Sea Use ---- 43
Human Settlements ---- 43
Transportation ---- 44
Crop Production ---- 48
Forestry ---- 52
Chemical Pollution ---- 56
Destructive Harvest and Control of Wild Species ---- 57
Biological Pollution (Exotic Species) ---- 61
Strategies for Conserving Biological Diversity ---- 64
The Gene Bank-Zoo-Botanical Garden Approach ---- 64
The Species Approach ---- 66
The Ecosystem Approach ---- 67
U.S. Policies on Biological Diversity ---- 69
The Endangered Species Act ---- 69
The Convention on International Trade in Endangered Species of Wild Fauna and Flora ---- 71
The Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere ---- 72
Additional Species-Oriented Programs ---- 72
Ecosystem-Oriented Programs ---- 73
References ---- 74

Chapter 3 WATER QUALITY ---- 81

Ground Water ---- 81
The Resource—Present Use and New Problems ---- 83
Volume and Trends ---- 83
Special Characteristics of Ground Water ---- 84
Human Health ---- 85
Risks Associated with Organic Chemicals ---- 85
EPA Regulation ---- 86
Sources of Contamination ---- 87
Industrial Landfills and Lagoons ---- 88
Municipal Landfills ---- 89
Septic Tanks and Onsite Sewage Disposal ---- 89
Mining and Petroleum Production ---- 91
Ground Water Conditions and Trends ---- 91
Availability of Data ---- 91
The National Perspective ---- 92
New York: One State's Experience ---- 95
Bedford and Gray: The Experience of Two Small Towns ---- 96
Policies and Programs ---- 97
The Federal Legal Framework ---- 97
The State Legal Framework ---- 99
Surface Water ---- 100
Conditions and Trends ---- 100
Rivers and Streams ---- 100
National Trends ---- 100
Fecal Coliform Bacteria (FC) ---- 101
Total Phosphorus (TP) ---- 102
Dissolved Oxygen (DO) ---- 104
Cadmium (Cd), Lead (Pb), and Mercury (Hg) ---- 105
Urban Pollution Trends ---- 108
Local Conditions ---- 108
Toxic Substances in Rivers and Streams ---- 109

	Page
Lakes	111
Estuaries and Coastal Waters	114
Drinking Water	116
Improving Environmental Data and Monitoring	120
Policies and Programs	122
Municipalities	122
Construction Grants	122
Operation and Maintenance Problems	123
Recreation Potential	124
Innovative and Alternative Technologies	124
Use of Sludge in Land Reclamation	126
Industries	126
The Effluent Guidelines Program	126
The Pretreatment Program	128
Permits, Compliance, and Enforcement	130
NPDES Permits	130
Consolidation of Permits	131
Nonpoint Sources of Pollution	133
Pollution from Unregulated Sources	133
Agriculture	133
Construction	134
Silviculture	134
Urban Runoff	134
Mining	134
Livestock	134
Septic Systems	134
Salinity	135
Remedies	135
EPA's Water Quality Management Program	135
Lakes	136
EPA's Clean Lakes Program	136
The Seven Lakes Study	137
References	138
Chapter 4 AIR QUALITY	146
Conditions and Trends	147
Urban Air Quality	147
Pollutant Standards Index (PSI)	155
Regional Air Quality and the Population at Risk	158
Trends in Ambient Concentrations	163
Emissions Trends	169
Current Issues	171
National Ambient Air Quality Standards	171
Long-Range Transport and Acid Rain	173
National Emissions Standards for Hazardous Air Pollutants	177
Compliance and Air Quality Management	179
State Implementation Plans	183
Indoor Air Quality	183
References	188
Chapter 5 TOXIC SUBSTANCES AND ENVIRONMENTAL HEALTH	190
Health Effects of Toxic Chemicals	192
Cancer Trends	192
Lung Diseases	195
Reproductive Effects	199
Widespread Exposures to Selected Toxic Substances	206
Lead	206
Caffeine	210

	Page
Diesel Exhaust	212
Issues in the Regulation of Toxic Substances	214
Hazardous Waste Disposal	214
Discovery of Hazardous Waste Dumpsites	214
Disposal Options	216
The Resource Conservation and Recovery Act	220
Enforcement of Hazardous Waste Laws	220
Export of Hazardous Wastes	221
Superfund Legislation	222
Compensation of Victims	223
Identifying Causes of Environmentally Related Disease	224
Sources of Compensation	224
Effectiveness of Programs as Deterrents to Pollution	227
Other Approaches	229
Trade Secrets	230
Health and Safety Data	231
International Initiatives	232
Testing under the TSCA	232
Testing Guidelines for New Chemicals	233
Test Rules	235
Reporting Provisions	240
Export Policy for Hazardous Substances	240
References	242
Chapter 6 ENERGY	251
National Energy Supply and Demand	256
Energy Demand	256
Energy Supply	261
Major Legislative Initiatives	262
The Energy Mobilization Board	263
The Energy Security Corporation	263
The Windfall Profit Tax	264
Assessment of DOE Environmental and Conservation Policies	264
Selected Issues in Energy Supply	265
The Carbon Dioxide Program	265
Biomass Energy	267
Biomass Production	268
End Use	268
Hydrogen	276
Fossil Fuel Issues	279
Outer Continental Shelf Oil and Gas	279
Exploration near the Flower Garden Banks	281
The Utility Oil Back-Out Program	281
Coal Leasing	283
Drilling the Overthrust Belt	284
Nuclear Issues	286
Response to the Accident at Three Mile Island	286
Radioactive Wastes	288
Nuclear Nonproliferation—The INFCE and NASAP Studies	289
References	290
Chapter 7 NATURAL RESOURCES	294
Public Lands	294
Parks, Refuges, Rivers, and Trails	298
Alaska	298
National Park Management	300
New National Parks	301
Wild and Scenic Rivers	301

	Page
National Trails	302
Forests	302
Forest Management	302
Integrated Pest Management	304
National Forest System Wilderness Review	305
Mount St. Helens	306
Lake Tahoe Basin	307
BLM-Administered Lands	307
Management Processes	307
Agency Coordination	309
BLM Wilderness Review	309
Rangelands	310
Agriculture	311
Continuing Federal Efforts To Control Erosion	312
Energy Production—Prospects and Problems	316
Resource Conservation Strategies	320
Conservation Incentives	320
Integrated Pest Management	321
Making Policy Work—The Economics of Farm Production and Conservation	322
Water Resources	324
Implementing the Administration's Water Policy	325
State Water Resources Programs	326
Wetlands Protection	327
Congressional Actions	327
Mineral Resources	330
The COSMAR Study	330
Phosphate	331
References	332
Chapter 8 HUMAN SETTLEMENTS AND LAND USE	338
Growth Trends	339
National Trends	339
Regional Population Trends	339
Coastal Areas and Floodplains	343
Arid Lands and Desertification	346
The Rio Puerco Basin and Overgrazing	349
The San Joaquin Valley and Multiple Causes	352
Poor Drainage of Irrigated Land	352
Ground Water Depletion	354
Overgrazing	355
Off-Road Vehicles	357
Urbanization	357
Farming in Ranch Country	357
The Increasing Scarcity of Water	359
Conserving the Nation's Agricultural Lands	360
Land Use and Urban Development Policies	364
Tax Policy	365
Transportation Policy	365
References	366
Chapter 9 NEPA	370
Evaluating the NEPA Regulations	371
List of Federal Agencies	371
The Benefits of NEPA and the Regulations	371
Environmental Analysis of Nuclear Power Plant Accidents	373
Developments in the Courts	374
The *Strycker's Bay* Case	374

Page

The RARE II Case ---- 376
EIS Alternatives and the Need for an EIS Supplement ---- 379
Energy Resources ---- 379
Protection of Environmentally Sensitive Areas ---- 382
EIS Costs ---- 382
NEPA Litigation ---- 383
References ---- 384

Chapter 10 ECONOMICS ---- 387

Regulation and Productivity ---- 387
Economic Incentives ---- 389
Cost-Benefit Analysis and the Courts ---- 392
Expenditures on Environmental Quality ---- 393
Accuracy of Pollution Control Cost Estimates ---- 396
References ---- 399

APPENDICES

A Public Opinion on Environmental Issues ---- 401
B The National Environmental Policy Act of 1969, as Amended ---- 426
C The Environmental Quality Improvement Act of 1970 ---- 431
D Executive Order 11514, as Amended by Excutive Order 11991 (Sections 2(g) and 3(h)), May 24, 1977, Protection and Enhancement of Environmental Quality ---- 434
E Regulations for Implementing the Procedural Provisions of NEPA ---- 437
F Federal Agency NEPA Contacts ---- 476
G Members and Staff of the Council on Environmental Quality ---- 485

INDEX ---- 486

TABLES

1–1 U.S. Ocean Disposal of Wastes, 1973–79 ---- 17
1–2 U.S. Ocean Disposal of Low-Level Radioactive Wastes, 1967–79 ---- 19
1–3 U.S. Tanker Incidents and Oil Spills, 1969–79 ---- 21
1–4 International Whaling Commission Commercial Whaling Quotas, 1974–81 ---- 23
2–1 Selected Plants and Animals Extirpated or Greatly Reduced by Excessive Harvest or Pest Control Activities ---- 59
2–2 Number of Animals and Plants Designated or Proposed as Endangered or Threatened Species ---- 70
3–1 Fresh Ground Water Uses, 1950–75 ---- 84
3–2 Counties with More Than 50,000 and 100,000 Housing Units Using Onsite Domestic Waste Disposal Systems ---- 90
3–3 Concentrations of Selected Synthetic Organic Compounds in Raw and Finished Ground Water ---- 93
3–4 Organic Compounds Found in Ground Water as Reported by the States ---- 94
3–5 Organic Chemicals Detected in Community Water Supply Wells, Nassau County, 1978 ---- 95
3–6 The 10 Synthetic Organic Compounds Most Commonly Detected in Public Water System Wells in New York State, 1979 ---- 96
3–7 Thresholds Used in the CEQ Analysis of National Surface Water Quality ---- 101
3–8 Phosphorus Loadings of the Great Lakes, 1978 and Proposed ---- 114
3–9 Thresholds Used in the CEQ Analysis of National Estuary Water Quality ---- 115

		Page
3–10	Compliance with Maximum Allowable Contamination Levels, 1979	120
3–11	Primary Industry Discharges of Toxic Priority Pollutants, 1979	128
3–12	Industries Discharging into Municipal Sewage Treatment Plants, 1979	129
3–13	NPDES Permits Issued as of February 12, 1980	130
3–14	EPA Enforcement Actions for Violation of NPDES Permits	132
4–1	Ranking of 40 Standard Metropolitan Statistical Areas Using the PSI, 1976–78	154
4–2	Comparison of PSI Values, Pollutant Levels, and General Health Effects	156
4–3	Frequency of Violations for the 10 Federal Regions by Criteria Pollutant, 1978	162
4–4	National Emissions Estimates, 1970–78	170
4–5	National Ambient Air Quality Standards	172
4–6	Estimated Number of Tall Stacks Constructed in the United States, 1970–79	175
4–7	Regional Distribution of Tall Stacks Built by Electric Utilities, 1970–79	176
4–8	Sources of Hazardous Pollutants with Established Emissions Standards	177
4–9	Compliance Status of Major Air Pollution Sources, 1980	181
4–10	Number of EPA Enforcement Actions, 1977–79	182
4–11	Recommended and Promulgated Formaldehyde Exposure Limits	186
4–12	Indoor-Outdoor Formaldehyde Concentrations Measured at an Energy-Efficient Residence, 1979	187
5–1	Occupational Exposures in Trades Employing Large Numbers of Women	202
5–2	Effects of Environmental Chemicals and Drugs on Male Reproduction, from Human Studies	204
5–3	Global Lead Emissions from Natural Sources and Human Activities	209
5–4	Mean Human Consumption of Caffeine	211
5–5	Total U.S. Industrial Hazardous Wastes	217
5–6	Common Hazardous Wastes	217
5–7	Costs of Environmentally Sound Methods for Disposal of Hazardous Wastes	219
5–8	Sources of Income for Severely Disabled Adults—Ages 20–64, 1972 and 1974	228
6–1	Energy Consumption per GNP Dollar, 1973–79	257
6–2	Representative Forecasts of U.S. Total Energy Consumption for the Year 2000	257
6–3	Growth Rates and Share of Total Energy Consumption by Source, 1979	259
6–4	Energy Production by Source, 1973–79	262
6–5	Net Energy Imports by Source, 1973–79	263
6–6	Significance of Long-Term Ecosystem Impacts on Biomass Fuels—Production	269
6–7	Significance of Health Hazards from Biomass Fuels—Conversion	272
6–8	Emissions from Selected Residential Space Heating, Power Generation, and Transportation Sources	277
7–1	Growth of Special Management Conservation Systems, 1969–79	298
7–2	Acres Eroding, Four Major Crops	313

Page

7–3 Plant Nutrients Contained in Crop Residues and in Commercial Fertilizer Applied under Conventional Cropping Patterns ... 317
7–4 Amount of Essential Plant Nutrients Lost under Existing Cropping Patterns for Three Common Tillage and Residue Management Systems ... 319
7–5 Regulatory Activities by Region, Fiscal Years 1978 and 1979 ... 328
8–1 Population of the United States by Metropolitan-Nonmetropolitan Residence, Race, and Spanish Origin, 1979 and 1970 ... 340
8–2 Provisional Estimates of the Resident Population of States, 1979, and Components of Change, 1970 ... 342
9–1 NEPA Litigation, 1979 ... 384
10–1 Estimated Incremental Pollution Abatement Expenditures, 1979–88 ... 394
10–2 Estimated Total Pollution Abatement Expenditures, 1979–88 ... 397
10–3 Ratio of Estimated to Actual Pollution Control Expenditures in Selected Industries ... 399

FIGURES

1–1 Estimated Ozone Reductions Resulting from Various Release Rates of Chlorofluorocarbons ... 14
1–2 Volume of Dredged Material from U.S. Harbors and Waterways Dumped into the Oceans, 1979 ... 18
2–1 World Population Growth, 500 B.C.–A.D. 2000 ... 42
2–2 Relationship between Number of Species and Island Size ... 45
2–3 Change in Ecological Diversity and Species Composition in a Hypothetical Ecosystem ... 47
2–4 Geographical Areas of Exceptional Genetic Diversity for Crop Plants (Vavilov Centres) ... 50
2–5 World Distribution of the House Sparrow ... 63
3–1 Sources of Ground Water Contamination ... 88
3–2 Fecal Coliform Bacteria, 1975–79 ... 102
3–3 Total Phosphorus, 1975–79 ... 103
3–4 Dissolved Oxygen, 1975–79 ... 104
3–5 Total Cadmium, 1975–79 ... 105
3–6 Total Lead, 1975–79 ... 106
3–7 Total Mercury, 1975–79 ... 107
3–8 Pesticide- and Nonpesticide-Related Water Pollution, 1978 ... 110
3–9 Lake Water Impairment ... 112
3–10 Degraded Water Quality Areas of the Great Lakes, 1978 ... 113
3–11 Status of Active Shellfish Harvesting Areas, 1977–79 ... 117
3–12 Estimated Number of Water Supply Systems in Violation of Federal Drinking Water Standards, 1979 ... 119
3–13 Number of States Reporting Water Supply Systems in Violation of Federal Drinking Water Standards, 1979 ... 121
4–1 Trends in PSI Levels in 23 SMSAs, 1974–78 ... 148
4–2 National Trends in Urban PSI Levels, 1974–78 ... 152
4–3 Estimated National Exposures to Pollutants above the Short-Term Ambient Health-Related (Primary) Standards, 1978 ... 159
4–4 Federal Air Pollution Control Regions ... 161
4–5 Annual Mean of Daily Maximum Ozone Concentrations at 23 California Sites, 1974–78 ... 164
4–6 Annual Mean of Daily Maximum Ozone Concentrations at 28 Non-California Sites, 1974–78 ... 165

		Page
4–7	Annual Mean of Daily Maximum Ozone Concentrations from Composite Average of California and Non-California Sites, 1974–78	166
4–8	Annual Arithmetic Average of Daily Maximum 8-Hour CO Concentrations, 1973–78	166
4–9	Annual Arithmetic Mean of 24-Hour Average SO_2 Concentrations, 1973–78	167
4–10	Annual Geometric Mean of Average TSP Concentrations, 1973–78	168
4–11	Composite Average Concentrations of Benzo(a)pyrene for 26 Urban Sites, 1966–77	179
4–12	Composite Average Concentrations of Benzo(a)pyrene with and without Coke Ovens for 26 Urban Sites, 1966–77	180
5–1	Age-Adjusted Rates for Major Causes of Death, 1900–1978	193
5–2	Age-Adjusted Cancer Death Rates, 1930–77	196
5–3	Annual Production of Synthetic Organic Chemicals, 1920–78	198
5–4	Age-Adjusted Death Rates for Chronic Obstructive Pulmonary Diseases, 1954–77	199
5–5	Relationship of Air Pollution Levels to Prevalence of Chronic Obstructive Pulmonary Disease by Age	200
5–6	Anencephaly and Spina Bifida Incidence in the Northeastern States, 1900–1970	201
5–7	World Lead Production	207
5–8	Sources of Lead Intake in Urban Smokers and Rural Nonsmokers	208
6–1	U.S. Gross Energy Consumption, 1900–1979	259
6–2	U.S. Passenger Car Efficiency Index, 1967–79	260
6–3	The Overthrust Belt	284
7–1	Soil Erosion in the Central States	314
8–1	Average Annual Precipitation	347
8–2	Status of Desertification in North America	349
8–3	The Rio Puerco Basin	350
8–4	The San Joaquin Basin	353

Chapter 1

THE GLOBAL ENVIRONMENT

If present trends continue, the world in 2000 will be more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now. Serious stresses involving population, resources, and environment are clearly visible ahead. Despite greater material output, the world's people will be poorer in many ways than they are today.

For hundreds of millions of the desperately poor, the outlook for food and other necessities of life will be no better. For many it will be worse. Barring revolutionary advances in technology, life for most people on earth will be more precarious in 2000 than it is now—unless the nations of the world act decisively to alter current trends.

***The Global 2000 Report to the President*[1]**

Signs of a degraded world environment and impoverished resources are evident as the 1980s begin. Over the next 20 years, as human numbers and needs increase rapidly, the earth's farmlands, fisheries, and forests, sources of energy and fresh water, atmosphere and oceans, and rich diversity of plant and animal species could be still more severely stressed—if present policies and trends continue.

Two major reports of the past year, one prepared for the President and the other for the United Nations Environment Programme (UNEP), warned of a decline in the earth's carrying capacity that could become progressively worse unless nations act now to change present trends. Both *The Global 2000 Report to the President,* a 3-year interagency study, and the *World Conservation Strategy,* prepared by the International Union for the Conservation of Nature and Natural Resources (IUCN) for UNEP and the World Wildlife Fund, emphasized the precarious condition of many of the earth's renewable resources: "Living resources essential for human survival and sustainable development are increasingly being destroyed or depleted. . . . The planet's capacity to support people is being irreversibly reduced in both developed and developing countries." [2]

According to *Global 2000,* there is an urgent need for changes in public policy throughout the world to lessen current stresses on world resources and the environment before options for effective

action are narrowed. The *World Conservation Strategy* outlined many actions that governments, conservation groups, and development assistance agencies can take to conserve living resources and achieve sustainable development. Several specific problems—increased food production in developing countries, conservation and wise management of tropical forests—also received close attention in reports of commissions, task forces, and international groups during the past year.

This complex of world resource and environment problems as they are today and as projected through the end of the century are discussed below. Issues relating to air, oceans, and wildlife are also described. Cooperative efforts between the United States and other countries to solve common environmental problems are brought up to date.

WORLD RESOURCES AND ENVIRONMENT: TRENDS AND STATISTICS

THE GLOBAL 2000 REPORT [3]

In his Environmental Message to the Congress in 1977, President Carter instructed the Council on Environmental Quality and the Department of State, working with other federal agencies, to study the "probable changes in the world's population, resources and environment through the end of the century." The study would serve as the "foundation for our longer-term planning." [4]

The pioneering study, released in July 1980, was the first attempt by the U.S. government—indeed, by any government—to project long-term trends in population, resources, and environment in an integrated way. The resulting projections, *not* predictions, of conditions in the year 2000 assume no changes in public policies, no revolutionary advances in technology, and no wars or other major disruptions.

One of the study's principal findings is that rapid growth in world population will change little by 2000. Even with steadily declining birth rates, the world population growth rate will slow only marginally, from 1.8 percent to 1.7 percent per year. In terms of numbers, the population will be growing faster in 2000 than today, adding about 100 million people instead of 75 million each year. More than 90 percent of the growth will take place in poorer, less-developed countries, whose share of the total population will rise from 72 to 79 percent.

The gross national product is expected to rise substantially, with per capita increases of more than 50 percent. This growth will be distributed unequally. In most poor countries, GNP per capita will remain low, averaging less than $600 per capita (1975 dollars) in 2000. The GNP per capita will rise substantially in some less

developed countries (LDCs), especially in Latin America; for example, increases of 50 to nearly 60 percent are expected in Mexico and Brazil, with per capita GNP rising to $1,600-1,800 per year. But in the populous nations of south Asia, the annual per capita GNP is expected to remain below $200.

By every measure of material welfare that the study provides—per capita GNP, consumption of food, energy, and minerals—the gulf between rich and poor widens.

By 2000 world food production is projected to increase 90 percent from its 1970 level. Per capita, the rise is less than 15 percent, with the largest share of the increase going to countries that are already well fed. South Asia, the Middle East, and North Africa scarcely improve; in the poorer African countries south of the Sahara, per capita food consumption will decline below present inadequate levels. At the same time, the real price of food is expected to double. Because most good land is already being used, arable area is expected to increase only 4 percent. Thus higher food output will have to be derived almost entirely from higher yields. Most of the elements that contribute to high yields—fertilizer, pesticides, power for irrigation, fuel for machinery—depend heavily on oil and gas.

During the 1990s, world oil production is expected to approach maximum capacity, even with rapidly increasing petroleum prices. According to the study projections, the richer industrialized nations will be able to command enough oil and other commercial energy supplies to meet demands through 1990. But with the anticipated price rises, many LDCs will have increasing difficulty meeting energy needs. For the one-quarter or more of the world population dependent on wood for fuel, the outlook is bleak. Needs for fuelwood are expected to exceed available supplies by one-quarter before the end of the century.

Per capita supplies of other essential resources—fresh water, timber, marine fish—will also decline, and prices will rise. The growing stock of wood per capita is expected to drop almost one-half, with most of the loss in the LDCs. The harvest of marine fish, which leveled off in the 1970s in spite of increased fishing efforts, will probably not increase. Per capita water supplies will decline one-third because of population growth alone, and rising demands will compete for available supplies.

In parts of the world, elemental human needs for food, shelter, and fuel are already causing severe stress on the environment. These stresses are expected to worsen. As much as 40 percent of the remaining forests in less developed countries may vanish by 2000, with consequent erosion of soil; silting of lakes, reservoirs, and rivers; and shortages of water in dry seasons and flooding after rains as the earth loses its capacity to absorb, store, and release water. Desertification—the degradation of grasslands and croplands to desert-like conditions—is already claiming an area equal to that

of Maine each year; this process is likely to accelerate. Agricultural soils will also deteriorate because of erosion (aggravated by deforestation), loss of organic matter, and the waterlogging and salinity that often accompany irrigation.

Another serious problem is possible large-scale changes in the earth's atmosphere. The concentration of carbon dioxide in the atmosphere is increasing because of the burning of fossil fuels and possibly because of the losses of world forests and soil humus. Rising concentrations of atmospheric CO_2 lead to a warming of the earth, possibly with very serious effects on climate and world agriculture. At the same time, the ozone layer in the stratosphere, which protects the earth from damaging ultraviolet radiation, is being depleted by chlorofluorocarbons and other chemicals. Concentrations of both CO_2 and ozone-depleting chemicals are increasing at rates that could significantly alter world climate and the upper atmosphere by 2050.

Acid rain from fossil fuel combustion, especially of coal, threatens damage to lakes, soils, forests, and crops. Radioactive and other toxic substances are likely to spread throughout the world, endangering human health and the natural environment. Increasing pollution and destruction of habitat will also affect fresh water and marine fisheries.

As tropical forests and other habitats disappear, the potential loss of species is unprecedented. Hundreds of thousands of irreplaceable plant and animal species—perhaps as much as 20 percent of all species—could be lost by 2000.

A major conclusion of *Global 2000* is that the federal government requires a much better capability to make long-range forecasts as a foundation for planning and decisions of worldwide significance. The government's projective models used in the study are strong in many respects; some are especially rich in regional detail. But the models for food, population, energy, and other sectors were not designed to be used together. As a result, there are serious gaps, inconsistencies, and contradictions among the models. For example, most of the projections simply assume that resource needs in a given sector—needs for capital, energy, water, minerals—will be met, regardless of needs in other sectors.

Despite the difficulties of making 20-year projections, the report is an important beginning. It contains the most internally consistent set of population, resource, and environmental projections yet developed by government agencies.

The study's detailed analysis of its own projections and comparison with other work leads to the overall conclusion that if present trends continue, the result will be worsening poverty and human suffering, resource waste, environmental destruction, and a rising potential for international strife. It should be emphasized, however, that the study projections were based on the assumption that public policies regarding population stabilization, resource conservation,

and environmental protection will remain unchanged through the century. In fact, there is reason for hope. Policies are beginning to change. Many nations are beginning to replant cutover forests, conserve energy, and make family planning measures widely available. Yet the efforts so far are not nearly enough.

On receiving the *Global 2000* report, President Carter established a Presidential Task Force on Global Resources and Environment, to be headed by the Chairman of the Council on Environmental Quality and to include the Secretary of State, the Assistant to the President for Domestic Affairs and Policy, the Director of the Office of Science and Technology Policy, and the Director of the Office of Management and Budget.[5] The President directed other federal agencies to cooperate with and support Task Force efforts. He asked the Task Force to report as soon as possible with recommendations for action in problem areas needing priority attention. At the same time, he directed the State Department to raise the issues identified in *Global 2000* in all appropriate international meetings.

For immediate action on one critical problem, he directed all relevant federal agencies to respond within 60 days to recommendations of the Interagency Task Force Report on Tropical Forests, described below. In receiving these responses, the Tropical Forests Task Force will act as an arm of the Presidential Task Force.

THE WORLD CONSERVATION STRATEGY

The *World Conservation Strategy*[6] grew out of a 3-year IUCN study in which hundreds of scientists from many countries participated. It describes stresses on the world environment and resources, pointing out the fact that "hundreds of millions of rural people in developing countries, including 500 million malnourished and 800 million destitute, are compelled to destroy the resources necessary to free them from starvation and poverty."[7] It makes recommendations for managing world living resources wisely and for achieving sustainable development—based on sound resource management—in poor countries.

The *Strategy* sets out three broad objectives. The first is to maintain natural processes and life support systems on which human survival and development depend. It calls for regeneration and protection of soils, recycling of nutrients, and cleansing of polluted waters. The most threatened life support systems today are agricultural, forest, and coastal and fresh water ecosystems.

The second goal is to preserve biological diversity. Diverse species are essential to the functioning of many ecological processes. Biological diversity also makes it possible to improve plant varieties and breeds of domestic animals; provides new foods, fibers, and drugs; allows technical innovation; and ensures continued supplies for industries that use living resources. But biological diversity is

In overcrowded Buenaventura, Columbia, people are living in an estuary in order to be near employment (Elliott A. Norse).

rapidly shrinking. An estimated 25,000 plant species and more than 1,000 vertebrate species and subspecies are known to be threatened with extinction. These figures do not include invertebrates such as mollusks and corals, whose habitats are being destroyed. Estimates that take these species into account, like the *Global 2000* projections, suggest that ½–1 million species will have disappeared by the end of the century. The value of biological diversity is the subject of Chapter 2.

The third major goal is to ensure the sustainable human use of species and ecosystems, especially fish and other wildlife, forests, and grazing lands, which support millions of rural communities and major industries.

Priority requirements for meeting the principal goals include the following:

- Reserve good cropland for crops
- Manage cropland using ecologically sound methods
- Manage watershed forests and pasture to protect the watershed
- Manage coastal wetlands and shallows to maintain the processes that support fisheries
- Manage land and water uses to prevent extinction of species
- Preserve as many varieties as possible of crop and forage plants, timber trees, livestock, and their wild relatives
- Determine the productive capacity of exploited species and ecosystems and maintain yields at sustainable levels
- Regulate stocking of grazing land
- Allocate timber concessions prudently and manage them using environmentally sound methods.

The *Strategy* also sets forth an institutional and planning framework for conservation of living resources as a guide for governments and private organizations.

WORLD HUNGER

The capacity of the earth to provide enough food for all is a crucial concern of both *The Global 2000 Report* and the *World Conservation Strategy*. This problem was examined in detail by the Presidential Commission on World Hunger in a report issued in March 1980.[8]

A crisis of global food supply—even more serious than the current energy crisis—could occur within 20 years, according to the Commission report. Such a crisis appears likely unless steps are taken now to increase food production significantly in the developing nations. Hunger can be eliminated, but to do so will require a continuing attack on the interrelated problems of poverty, population growth, food production and distribution, employment, and income.

The major world hunger problem today is not famine or outright starvation; it is chronic undernutrition. The problem is growing, with more ill-fed people in the world than ever before—some 800 million outside the Communist countries.

World hunger has many related causes, some of them technical or logistical. But "the central and most intransigent cause is poverty. Hunger, therefore, is primarily a political, economic, and social problem." [9] The report emphasized the need both to increase food production in the developing countries on a self-reliant basis and to ensure more equitable access to food for all.

In underscoring the importance of environmental protection, the Commission called for major improvements in how the world's land and water resources are used. "Rising global demands for food must be met within resource limits—of land, water, energy, and agricultural inputs." [10] There can be no lasting solution to world hunger if serious degradation of soils, grasslands, water resources, forests, and fisheries continues.

The Commission recommended that the United States focus on the elimination of hunger in its relations with the developing countries. Development aid should be increased to the level recommended by the UN (0.7 percent of GNP). Developing countries themselves must take decisive steps to increase food production and distribute food equitably, but the United States, as the largest producer, consumer, and trader of food, has a key role in an international effort.

WORLD FORESTS

A most serious threat to the biosphere is the rapid disappearance of tropical forests. In many tropical forests, the soils, terrain, tem-

Nurse logs in a temperate rain forest, Olympic National Park, Washington. The soil in rain forests can be so nutrient poor that young trees grow primarily on fallen nutrient-rich logs (Elliott A. Norse).

perature, patterns of rainfall, and distribution of nutrients are in precarious balance. When these forests are disturbed by extensive cutting, neither trees nor productive grasses will grow again. Even where conditions are more favorable to regrowth, extensive clearance destroys the ecological diversity of tropical forests. These forests are habitat for the richest variety of plant and animal species on earth.

As *Global 2000* and other studies have pointed out, extensive cutting of tropical forests is causing loss of agricultural soils, siltation of rivers, and intensified flooding in many less developed countries. If present trends continue, tropical deforestation could be responsible for the extinction of as much as 10 percent of the world's plant and animal species by the year 2000. Further, added to the major effects of fossil fuel burning, extensive loss of forests might aggravate the rising concentrations of CO_2 in the earth's atmosphere and thus eventually contribute to unprecedented human-caused changes in world climate.

The Interagency Task Force on Tropical Forests, led by the Departments of State and Agriculture, reported that tropical forests are in jeopardy.[11] The Task Force found that the United States has a vital interest not only in caring for its own tropical forests but also in helping other nations protect and sustain their much more extensive tropical forests.

In his 1979 Environmental Message, the President noted progress of this Task Force and directed all relevant federal agencies to give high priority to world forest issues in their budget and program

planning. He encouraged U.S. participation in efforts with other countries to protect and manage forests wisely.[12]

The Task Force reported worldwide losses of closed tropical forest at 10–20 million hectares (24–48 million acres), or 1–2 percent per year. (The smaller figure is about the size of Virginia, the larger about the size of South Dakota.) Loss rates in individual countries are far higher. Reports compiled in the middle 1970s showed that Thailand had lost one-fourth of its forest cover in 10 years; the Ivory Coast lost one-third in only 8 years; Costa Rica lost one-third in about 10 years.[13] In addition, the biological and commercial quality of many forest areas left partially standing is deteriorating.

The Task Force report did not condemn forest cutting per se but recognized the need to manage tropical forests for both short- and long-term benefits. To do so would require management for sustained yield timber production and maintenance of other values—ecological, scientific, aesthetic, and recreational. The future of tropical forests will be determined largely by broad policy decisions on rural development, food production, energy, land use, and population growth. Principal direct causes of tropical forest loss are the intense and increasing needs of people seeking food, fuelwood, wood products, and shelter. Underlying these needs are fundamental problems of unequal land tenure, lack of employment, lack of advanced agricultural methods, and rapid population growth.

The Task Force set forth objectives for the protection and wise management of tropical forests—cooperation with other countries to improve tropical forest monitoring, preservation of unique forests and ecosystems and protection of indigenous human cultures, training of land use planners and tropical forest managers, encouragement of low-cost energy alternatives to overuse of fuelwood and charcoal, and planting of village woodlots. Besides recommending these direct measures, the report set a goal of doubling the worldwide rate of tree planting within 5 years.

In addition to international efforts, the report suggested ways in which the United States could help conserve tropical forests. They included managing U.S. tropical forests in exemplary fashion, supporting domestic research for protection and management of tropical forests, expanding training for tropical forest management and offering it to specialists from other countries, and encouraging public and commercial entities to conduct their business in ways that promote good stewardship of tropical forests. As noted earlier, the President has directed relevant federal agencies to report in detail on their plans for carrying out these recommendations.

Two reports from the National Academy of Sciences underscored the concerns and conclusions of the Interagency Task Force on Tropical Forests. The Committee on Research Priorities in Tropical Biology of the National Research Council concluded:

> The tropical forests of the world are being altered so rapidly that most will not exist in their present form by the close of the century.[14]

> Even though tropical forest may persist in western Brazilian Amazonia and Central America for another 40 or 50 years, in most other areas it will be reduced much sooner to scattered degraded remnants . . . and to a few parks and reserves.[15]

The Committee considered of extreme importance a research program that would

- Accelerate the pace of the biological inventory of the tropics, at least doubling present international funding
- Increase the number of taxonomists studying tropical organisms from 1,500 to 6,000–7,500 and develop local institutions for training personnel
- Emphasize collection of specimens
- Increase conservation of genetic diversity in botanical gardens, seed banks, and zoos
- Begin studies in several basic ecosystems—New World rain forests with soils having both high and low fertility; New World tropical deciduous forest; moist tropical forest in Asian lowlands; tropical islands, grasslands and savannahs, and aquatic ecosystems.

In a report prepared for the Committee, tropical forest specialist Norman Myers examined trends, rates, and causes of tropical forest loss in parts of the world.[16] Virtually all lowland forests of the Philippines, peninsular Malaysia, and most of west Africa seem likely to be logged over by 1990 at the latest. Almost all of Indonesia's lowland forests are scheduled for timber cutting by 2000, one-half by 1990. Bangladesh, Thailand, India, and Sri Lanka could all lose much or most of their forest by 1990. Central America's moist forests could all but disappear by 1990.

The most significant direct cause of forest loss is "forest farming," including traditional shifting cultivation (slash and burn agriculture). Shifting cultivators clear a small patch of forest, burning the native vegetation and using the ash as fertilizer. When the nutrients in the ash are exhausted, the farmer and his family move on, leaving the recently used cropland fallow for several years until wild plants have grown again, making more nutrients available. The system is sustainable where soils and terrain are favorable and population pressure is not too great. Today, however, shifting cultivators in many tropical forests are shortening fallow periods and using the land too intensively, both because populations are growing rapidly and because the forest available to traditional cultivators has been lost to competing demands, such as large plantations and industrial forests. Moreover, subsistence peasants are moving into forests for lack of land or jobs elsewhere. Other factors leading to deforestation—timber harvesting, planned agriculture, and cattle raising—are steadily gaining in importance. The report concludes that annual forest losses may well be nearer 20 million hectares than 10 million.

Recognizing that the principal causes of deforestation are inseparable from complex and difficult issues of world poverty and inequities, the Interagency Task Force on Tropical Forests also discussed

in some detail possible U.S. influences, both positive and negative, on tropical forest loss.[17] Among the factors that may aggravate forest loss are U.S. demand for wood; commercial forestry by U.S.-based firms (about 30 are active in tropical forests, most of them in Southeast Asia); U.S. demand for beef raised on Central and South American ranches carved out of forest land; and U.S. investment in the ranches. The report indicated that some U.S. development aid projects may also adversely affect forests but that some projects in tropical countries (Panama, Mauritania, and Senegal, for example) are now being planned to protect or restore forests.

The United States is a fairly substantial market for tropical forest products. The Task Force noted that in 1977 imports of tropical wood and wood products totaled $512 million, 12 percent of the tropical wood exports from harvesting countries (mainly Indonesia, Malaysia, and the Philippines) and processing countries (mainly South Korea, Taiwan, and Japan). These imports represent only 1–2 percent of all wood and 3 percent of hardwood used in this country.[18]

The demand for beef by the developed nations appears to be increasing pressure to convert forest into rangeland in Central America and the Amazon Basin. In the 20 years from 1958 to 1978, U.S. beef imports nearly quadrupled, rising from 374 million pounds to 1,485 million pounds per year. Australia and New Zealand are still the major suppliers of U.S. beef imports (70 percent), but Latin American countries now contribute about 15 percent of the total. In 1958, only three Central American countries exported beef to the United States, and their total exports were about 3 million pounds. By 1978, six Central American nations exported more than 220 million pounds of beef to the United States.[19]

Some less developed countries (LDCs) may view the sale of wood products and beef to developed countries as an attractive way of raising their gross national product and improving their foreign exchange. Yet if timber cutting or cattle ranching seriously damages land, water, and living resources, the long-term costs may far outweigh the benefits. Further, some of these projects may be of dubious social value. For example, as Costa Rica increased beef exports about fivefold in 15 years,[20] domestic beef consumption fell one-half.[21] Although the effects of this change are not certain, they may well include impoverishment of the national diet.

U.S. interests in preservation and wise management of tropical forests range from commercial and consumer interests, such as a market in tropical countries for U.S. goods, to such policy considerations as the U.S. commitment to world peace and social stability, economic and social progress in the LDCs, and maintenance of the earth's basic life support systems. The United States shares with all other countries an interest in tropical forests as a regulator of climate and habitat for millions of species whose potential benefits to humankind cannot be estimated.

THE ATMOSPHERE

There is a growing realization that the earth's atmosphere could be permanently and disastrously altered by human actions. The burning of fossil fuels and perhaps the cutting of forests without compensatory replanting are causing a steady, measurable buildup of carbon dioxide in the atmosphere that threatens widespread climate change. The burning of fossil fuels, especially coal, also leads to the formation of acids in the atmosphere which may fall in rain or snow hundreds of miles from their source. The effects of acid precipitation are not fully understood. They may be damaging forests, crops, and soils seriously. It is already known that acid precipitation has eliminated fish from hundreds, perhaps thousands, of lakes in the United States and Canada as well as in western Europe, especially Scandinavia.[22] The continuing release of chlorofluorocarbons is reducing the ozone concentration in the stratosphere, with potentially far-reaching effects on human health and the environment.

The atmosphere knows no national boundaries. The activities of nations, individually and collectively, can create pollution that is detrimental to other nations or to all humanity. This fact underscores the need for international cooperation in understanding and controlling alteration of the world atmosphere.

GLOBAL CARBON DIOXIDE ACTION PLAN

A World Meteorological Organization (WMO) study group recently concluded that there is now little doubt that rising concentrations of carbon dioxide in the atmosphere will cause global warming.[23] In doing so, the WMO Commission for Atmospheric Sciences agreed with prevailing scientific opinion that rising concentrations of CO_2 will result in warming of the lower atmosphere, with more marked effects at the poles than at lower latitudes. The general global warming and the weakening of the temperature difference between the equator and the poles will change patterns of atmospheric circulation and climate. The climate changes cannot be predicted accurately, but they could adversely affect agriculture (for discussion of CO_2 and the greenhouse effect, see Chapter 5, Energy).

The WMO, UNEP, and the International Council of Scientific Unions have recommended an international approach to the CO_2 problem in several steps: an environmental assessment by experts meeting in the fall of 1980, a plan of action by early 1981, and a major conference on carbon dioxide and climate in late 1981.[24] Planners expect the conference to explore all facets of the carbon cycle and its relationship with climate and to help develop international scientific consensus on the issue.

ATMOSPHERIC OZONE DEPLETION

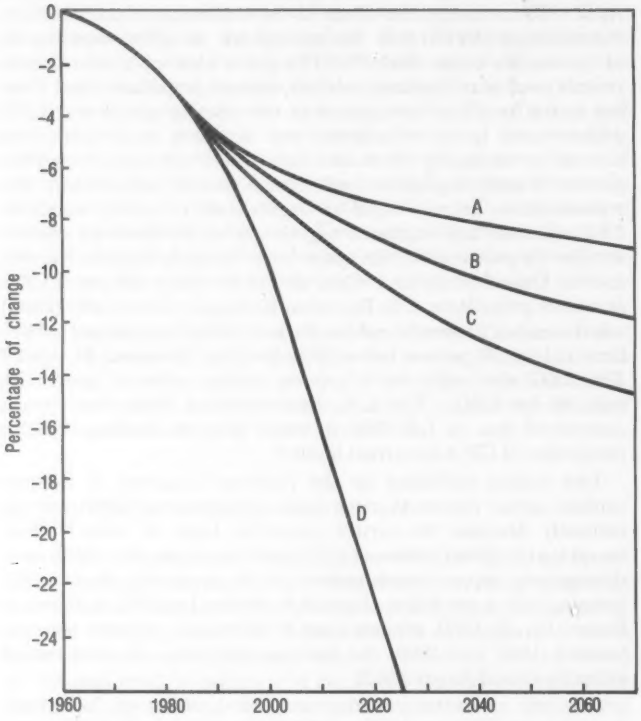
Representatives of the United States, Canada, Denmark, the Federal Republic of Germany, the Netherlands, Norway, Sweden, and the Commission of the European Communities met in Oslo in April 1980 to consider the effects of the continuing release of chlorofluorocarbons (CFCs) into the atmosphere, including deterioration of the earth's ozone shield.[25] CFCs are a class of chemical compounds used as refrigerants, solvents, aerosol propellants, and blowing agents for foam. Participants in the meeting agreed that CFCs deplete ozone in the stratosphere and that as a result there is an increase in damaging ultraviolet radiation which can affect plant growth, marine organisms, and human health unfavorably. The representatives acknowledged an urgent need to reduce worldwide CFC emissions and suggested negotiating an international convention for the protection of the ozone layer. Sweden, Canada, Norway, and the United States have taken actions to control the use of CFCs as aerosol propellants. The European Economic Community (EEC) asked member nations to reduce the use of CFCs as aerosol propellants at least 30 percent below 1976 levels by December 31, 1981.[26] The EEC also called for a cap on member nations' production capacity for CFCs. The U.S. Environmental Protection Agency announced that in fall 1980 it would propose limiting domestic production of CFCs to current levels.[27]

Two studies published by the National Academy of Sciences confirm earlier reports that the continued release of CFCs will significantly decrease the earth's protective layer of ozone.[28] They found that if global release of CFCs were to continue at 1977 rates, stratospheric ozone concentrations would eventually decline 16.5 percent, with a reduction of about 8 percent by 2030, as shown in Figure 1–1. If CFC releases were to increase 7 percent per year between 1980 and 2000, the eventual depletion of ozone would probably exceed 30 percent.[29]

As ozone concentrations decrease, the intensity of biologically damaging ultraviolet radiation (DUV) in natural daylight increases. A 16 percent ozone decrease will produce a DUV increase of about 44 percent at mid latitudes, and a 30 percent ozone decrease would increase DUV approximately 100 percent.[30] The National Academy report predicts that a 16 percent ozone depletion would eventually cause several thousand more cases of melanoma per year in the United States, many of them fatal, and several hundred thousand more cases of other skin cancers. A 16–30 percent depletion of ozone is likely to reduce crop yields of several kinds of plants; data are not presently available to quantify these losses. Larval forms of several important seafood species as well as microorganisms at the base of the marine food chain would suffer appreciable killing as a result of a 16–30 percent ozone depletion. Continued CFC release could eventually cause a slight warming of the earth's surface—in addition

Figure 1-1

Estimated Ozone Reductions Resulting from Various Release Rates of Chlorofluorocarbons



A Constant 1977 release rates.
B 1977 release rate until 1983, from then on reduced by 25 percent.
C 1977 release rate until 1983, reduced by 25 percent until 1988, reduced an additional 25 percent after 1988.
D 1977 release rate until 1980, increased 7 percent per year until 2000, then constant release rate at the year 2000 rate.

Source: National Academy of Sciences, Panel on Stratospheric Chemistry and Transport, *Stratospheric Ozone Depletion by Halocarbons: Chemistry and Transport* (Washington, D.C., 1979), p. 176.

to that predicted from a CO_2 buildup. Noting that the United States has already taken steps to reduce CFC emissions, the Academy committees issuing the reports concluded that further unilateral reductions can have only limited global effects and urged that an international strategy be developed.

WORLD CLIMATE IMPACT STUDIES

One of four major components of the World Climate Program, established by the Eighth World Meteorological Congress in 1979,[31] is its Impact Studies Program. The first phase of the Program, to begin in 1980 and extend through 1983, includes efforts to

- Reduce the vulnerability of food systems to climate change
- Anticipate impacts of climate changes caused by human activity
- Improve the science of climate impact studies
- Identify human activities that are most sensitive to climate.

The Program will be carried out by the United Nations Environment Programme. Although UNEP has not yet formally adopted the Program, the UNEP Governing Council has authorized establishment of a Program scientific advisory committee and initiation of a few related projects.[32] The primary objective of the Program is to make climate a consideration in national policymaking on water, food, and energy supplies.

OCEANS

There seems to be a natural tendency to regard the oceans as a convenient, limitless receptacle for wastes. Experience and understanding are teaching us that, despite their vastness, the oceans' natural capacity to receive, decompose, and recycle wastes has limits. This understanding is expressed in a growing number of international agreements—such as the conventions controlling pollution of the oceans by oil and chemical tankers[33] and the 1972 London Ocean Dumping Convention,[34] which regulates the kinds of materials that may be dumped into the oceans. Under the Convention, no dumping is to be allowed without a permit, and hazardous substances require special permits. But as problems of waste disposal on land multiply, pressures to use the oceans as a dumping ground become stronger.

Raw sewage and the sludge that remains after treatment are dumped in the ocean throughout the world. Spoils from the dredging of rivers and harbors, often containing heavy metals, persistent organic chemicals, and other toxic chemicals, are also dumped. Several European countries (principally Britain, Belgium, the Netherlands, and Switzerland) currently dump low-level radioactive wastes at a site in the North Atlantic. Japan anticipates beginning ocean dumping of such wastes, and the United States is evaluating the potential impacts of ocean disposal. The volume and types of wastes dumped, particularly toxic materials and radioactive wastes, clearly indicate the need for understanding the effects of these wastes and for continued, expanded international cooperation.

OCEAN DUMPING IN U.S. WATERS

The Marine Protection, Research and Sanctuaries Act,[35] passed in 1972, implements the London Ocean Dumping Convention in the United States. It prevents or strictly limits ocean dumping of any material that would adversely affect human health, welfare, or amenities; the marine environment or ecological systems; or economic potential. Under the Act, the Corps of Engineers grants permits for the dumping of dredged material, subject to the approval of the Environmental Protection Agency on sites, materials, and quantities. EPA grants permits for other materials, mainly industrial wastes and sewage sludge.

Ocean dumping of the waste materials regulated by EPA dropped from approximately 10.8 million tons in 1973 to 8.7 million tons in 1979, mostly because of a 49 percent decline in industrial dumping, shown in Table 1–1. Dumping of municipal sewage sludge has risen each year as cities treat more sewage in compliance with clean water requirements. Under the Act, dumping of municipal sludge and harmful industrial wastes is to end by 1981, but New York and other eastern cities report difficulty finding alternatives.[36]

The volume of dredged material dumped is several times greater than the total of other waste materials dumped. In 1979, 72.8 million cubic yards of silt dredged from U.S. harbors and waterways was dumped in the oceans (see Figure 1–2).[37] This amount is roughly equivalent to 67.4 million tons (compared with 8.7 million tons of other waste materials). Recent events suggest that a significant portion of these wastes is contaminated with toxic chemicals. If so, disposal of dredged materials may create difficult problems. Before agreeing to a Corps permit to dump dredged material, EPA analyzes the material for contamination by toxic metals, bacteria and viruses, and organic chemicals and assesses the suitability of the dumping site.

Like many waterways, New York Harbor is dredged regularly. So that the Port of New York could remain open, 8.4 million cubic yards of silt were dredged in 1979 and dumped 6 miles out from Sandy Hook.[38] In autumn of 1979, EPA observed bioaccumulation of PCBs in test samples from the Harbor. Approval of 15 permits was delayed pending further study. The bioaccumulation test that EPA used was new, and the results were difficult to relate to human health. EPA then decided that the concentration of PCBs was low enough for dumping to proceed, provided the contaminated spoil was covered with clean material after it was dumped. The first of the permits was issued in March 1980.[39]

PCB contamination in New York Harbor raised questions about ocean disposal of dredge spoils in general. PCBs are banned in the United States because of their toxicity and persistence. U.S. law and the London Ocean Dumping Convention to which the United States is a party require control of dumping potentially harmful substances in the ocean. Had the Corps denied a permit to dump New York

Table 1–1

U.S. Ocean Disposal of Wastes, 1973–79[a]

(tons)

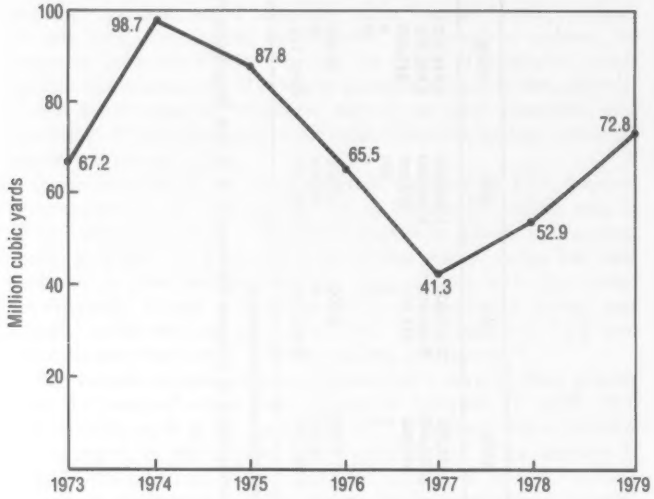
Type	1973	1974	1975	1976	1977	1978	1979
Industrial wastes	5,050,800	4,579,700	3,441,900	2,733,500	1,843,800	2,548,173	2,577,000
Sewage sludge	4,808,900	5,010,000	5,039,600	5,270,900	5,134,000	5,535,000	5,932,000
Construction and demolition debris	973,700	770,400	395,900	314,600	379,000	241,000	107,000
Solid wastes	240	200	0	0	100	0	998
Explosives	0	0	0	0	0	0	0
Incinerated							
Wood	10,800	15,000	6,200	8,700	15,100	18,000	36,000
Chemicals	0	12,300	4,100	0	29,700	0	0
Total	10,844,440	10,388,400	8,887,700	8,327,700	7,401,700	8,342,173	8,652,998

[a] Includes all dumping except dredge spoil, which represents 80–90 percent of all materials dumped.

Source: U.S. Environmental Protection Agency, *Ocean Dumping, 1979 Annual Report to Congress* (Washington, D.C.: U.S. Government Printing Office, 1980).

Figure 1-2

Volume of Dredged Material from U.S. Harbors and Waterways Dumped into the Oceans, 1979



Source: U.S. Army Corps of Engineers, *1979 Report to Congress on Administration of Ocean Dumping Activities* (Washington D.C.: U.S. Government Printing Office, 1980).

Harbor dredge spoils, the Harbor would have been closed to ocean-going ships by summer 1980 because it could not have been dredged. The extent and seriousness of toxic contamination of dredge spoil can be better evaluated as testing improves, with a larger number of silt samples tested for more substances.

RADIOACTIVE WASTE DISPOSAL

Since 1967, almost all ocean disposal of nuclear wastes has been conducted under international supervision and control. The London Ocean Dumping Convention of 1972 prohibits sea disposal of high-level wastes.[40] The International Atomic Energy Agency (IAEA) has developed recommendations for low-level waste dumping under the Convention which favor isolation and containment of wastes rather than dilution and dispersion in the water.[41] The minimum seabed depth for disposal recommended by IAEA is 4,000 meters. In addition, the Organization for Economic Cooperation and Development (OECD) requires that its members give prior notice of plans to dispose of low-level wastes at sea and that OECD's Nuclear Energy Agency assess all radioactive waste dumpsites.[42]

There are critical gaps in knowledge of what happens chemically and biologically to wastes deposited at deep sea sites—for example, where radioactivity leaking from canisters in the North Atlantic dumpsite is going and whether radioactive substances are being taken up by living organisms. To date, no multidisciplinary survey of the site has been conducted. OECD Nuclear Energy Agency experts called attention to this lack of information when they met in 1979 and recommended that a well-defined program for research and monitoring be developed within 12 months. They also recommended that dumping be permitted at the North Atlantic site during the next 5 years. The suitability of the site should be reconsidered, however, if dumping rates increase by a factor of 10. More than 600,000 curies of mixed alpha, beta, and gamma wastes have been dumped at the Atlantic site since 1967. The annual totals have progressively increased, reaching 84,400 curies in 1979, as shown in Table 1–2. The United States has urged that more stringent limits be imposed. At a meeting of the OECD Environment Committee in March 1980, the U.S. delegation urged that dumping not be permitted after 1981 unless an adequate site assessment is made and a monitoring plan is established.[43]

Table 1–2

Ocean Disposal of Low-Level Radioactive Wastes, 1967–79

Year	Dumped weight (metric tons)	Radioactivity (curies)	
		Alpha (actinides)	Beta, gamma
1967	10,840	250	7,600
1969	9,180	500	22,000
1971	3,970	630	11,200
1972	4,130	680	21,600
1973	4,350	740	12,600
1974	2,270	420	100,000 [a]
1975	4,460	780	60,500 [b]
1976	6,770	880	53,500 [c]
1977	5,605	958	76,450 [d]
1978	8,000	1,100	79,000 [e]
1979	5,400	1,400	83,000 [f]

[a] Almost exclusively tritium.
[b] Includes about 30,000 curies of tritium.
[c] Includes about 21,000 curies of tritium.
[d] Includes about 32,000 curies of tritium.
[e] Includes about 36,000 curies of tritium.
[f] Includes about 42,000 curies of tritium.

Source: R. S. Dyer, "Sea Disposal of Nuclear Waste: A Brief History," prepared for the Forum on Nuclear Waste Management: The Ocean Alternative, held by George Washington University Law Center, Washington, D.C., February 1980.

THE MEDITERRANEAN PROTECTION AGREEMENT

An international plan to control the principal causes of pollution in the Mediterranean Sea was adopted in May 1980. Eleven nations and representatives of the European Community signed the international agreement for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources.[44] Countries bordering the Mediterranean had previously agreed to control the discharge of pollutants from ships and aircraft and to control emergency spills of oil and other harmful substances.

The new agreement, negotiated through UNEP, concerns pollution originating on land, perhaps 85 percent of the pollutant load entering the Mediterranean. Controlling land-based sources is more difficult and costly than controlling sources at sea, for example, the oil from tankers. An important incentive for the 18 nations bordering the Sea to adopt the plan is the effect on tourism of an unsightly and unhealthy Mediterranean.

Signatory nations agreed to control pollution of the Mediterranean from industrial wastes, municipal sewage, and runoff of agricultural pesticides and fertilizers. The agreement includes a "black list" of pollutants that will be prohibited from entering the Sea because of their inherent toxicity, persistence in the environment, or bioaccumulation in the food chain. Pollution by a second "grey list" of less dangerous substances will be strictly controlled. The agreement will enter into force when ratified by six nations.

OIL SPILLS

The amount of oil spilled from tankers in 1979 was the highest on record. In 1978 there were 35 incidents, and 260,000 metric tons of oil were spilled. In 1979, there were 65 incidents involving 724,000 tons, as shown in Table 1–3.

On July 29, 1979, the *Atlantic Empress,* carrying 276,000 metric tons of crude oil, and the *Aegean Captain,* carrying 200,000 tons, collided in the Caribbean 50 miles northwest of Tobago. The exact volume of the spill is not known, but it probably exceeds the previous largest spill—216,000 tons lost from the *Amoco Cadiz* off France in 1978. The *Atlantic Empress* sank, taking 140,000 tons of cargo to the bottom. The remaining 136,000 metric tons burned or entered the sea. The *Aegean Captain* spilled 20,000 tons of its cargo; the rest remained aboard the damaged tanker.[45]

When the freighter *Mimosa* collided with the *Burmah Agate* about 45 miles from Galveston Harbor, the tanker caught fire and burned for 70 days. Of 51,000 tons of crude oil aboard, the Coast Guard was able to offload 20,800 tons, but an estimated 18,000 tons of oil were spilled into the Gulf and the remaining 12,000 tons burned. The spill contaminated the entire coast of Galveston Island and came ashore at Saint Joseph Island, northeast of Corpus Christi.[46]

Table 1–3

U.S. Tanker Incidents and Oil Spills, 1969–79

Year	Number of incidents	Spill (long tons)
1969	130	141,000
1970	74	267,000
1971	98	157,000
1972	77	260,000
1973	54	123,000
1974	50	169,000
1975	44	234,000
1976	36	262,000
1977	48	247,000
1978	35	260,000
1979	65	724,000

Tankers under 6,000 tons deadweight are excluded.

Sources: For 1969–77, U.S. Coast Guard, tanker casualty data base, Washington, D.C.; for 1978–79, Tanker Advisory Center, New York.

The Campeche Bay offshore well blowout caused the largest oil spill in history from any source. The IXTOC No. 1 well, drilled by Pemex, the Mexican national oil company, spilled an estimated 10,000–30,000 barrels per day from June 3, 1979, until March 23, 1980, when it was finally capped.[47] The total loss may well exceed 3 million barrels (about 425,000 metric tons). The oil slick and tar moved 700 miles north, reaching the Texas coast in early August. With a change in the direction of wind and currents in early fall, the slick moved back south.

Mechanical means of collecting the oil in Campeche Bay were employed with varying degrees of effectiveness until September. Then chemical dispersants were used extensively near the well site. Little information was available in mid-1980 on biological effects of the spill, but studies by Mexican authorities are due for release later in the year.

INTERNATIONAL EFFORTS TO CONTROL OIL POLLUTION

Two important agreements designed to prevent oil pollution from tankers were ratified by the Senate in July 1980.[48] Negotiated in response to proposals by the President, the agreements were signed at the 1978 International Conference on Tanker Safety and Pollution Prevention, sponsored by the Inter-Governmental Maritime Consultative Organization of the United Nations.

The agreements set stricter international standards for design and operation of oil tankers. For all tankers, they require segregated ballast or crude oil washing to control routine discharges of oil and use of inert gas systems to help prevent explosions in tanks contain-

ing petroleum vapors. For new tankers, segregated ballast tanks must be located on the outside of the ships to reduce the risk of accidental oil spills. The agreements also set requirements for dual radars, redundant steering controls, and automatic collision avoidance aids. They strengthen existing inspection and certification standards.[49]

So far five nations have ratified the agreements. To take effect, they must be ratified by 15 nations, constituting at least one-half the world merchant fleet tonnage. Meanwhile, the Coast Guard has implemented the standards for all ships calling at U.S. ports.[50]

Increasing international attention is being devoted to reducing pollution from offshore oil and gas operations. UNEP convened a working group of experts on international law which proposed legal measures to be taken by individual nations as well as recommendations for international agreement. The recommendations are not technical; rather, they identify aspects of offshore operations that should be subject to standards, and they propose general pollution control measures—requirements for safety, licensing and inspection of installations, monitoring and reporting of environmental effects, and notification to other nations when pollution problems occur.[51]

The Third United Nations Law of the Sea (LOS) Conference, which has been meeting since 1974, has considered a broad range of environmental issues. The agreed-upon LOS text encourages nations to enact laws and enter into international agreements to reduce marine pollution from offshore oil operations and seabed mining.[52]

WILDLIFE

WHALES

At its annual meeting in 1979, the International Whaling Commission (IWC) took several significant steps.[53] It indefinitely banned whaling from factory ships on the high seas (except for hunting the relatively numerous minke whales), thereby restricting whaling to coastal stations. It established a whale sanctuary in the Indian Ocean where no whale hunting will be allowed for 10 years. It reduced the quota on the commercially valuable but jeopardized sperm whales from 9,360 whales to 2,203 and reduced the quota for all whales from 19,526 to 15,656.[54] These measures represent important progress, although they fall short of the U.S. goal of a total moratorium on commercial whaling.

At its 1980 meeting, the IWC reduced the quota for all whales to 13,851 and for sperm whales to 1,320, as shown in Table 1–4. But proposals for a moratorium on all commercial whaling and on the taking of all sperm whales were defeated. The IWC explicitly defined the ban on high seas whaling to cover orcas (killer whales), 916 of which were taken by Soviet factory ships in the Southern Hemisphere in the 1979–80 season.

Table 1–4

International Whaling Commission Commercial Whaling Quotas, 1974–81

(number of animals)

Season	Species					
	Fin	Minke	Sei	Bryde's	Sperm	Total
1974–75	1,300	7,000	4,000	2,000 [a]	23,000	37,300
1975–76	585	9,360	2,230	1,363	19,040	32,578
1976–77	455	11,924	1,995	1,000	12,676	28,050
1977–78	459	8,645	855	524	13,037	23,520
1978–79	455	9,173	84	454	9,360	19,526
1979–80	604	12,006	100	743	2,203	15,656
1980–81	651 [b]	10,987	100	793 [c]	1,320	13,851

[a] Represents a combined quota of 2,000 Sei and Bryde's whales in the North Pacific.

[b] The official quota is 701, but Iceland has declared that it will take only 254 of its quota of 304.

[c] The official quota is 1,415, but 622 cannot be taken legally because of the moratorium on factory ship whaling and the Indian Ocean sanctuary.

Sources: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, *The United States and Whale Conservation* (Washington, D.C., 1978), p. 8; information provided by the National Oceanic and Atmospheric Administration.

The endangered bowhead whales, whose summer range includes the Bering, Chukchi, and Beaufort Seas, are a special problem for the United States. Although commercial hunting of bowheads, once intensive, ended in the early 1900s, subsistence whaling by North Slope Eskimos continues. The population of bowheads, estimated at 18,000 before commercial whaling began in 1851, was about 2,300 in 1979.[55] A sharp rise in whale killing by the Inupiats in the mid-1970s and the size and endangered state of the remaining stock led the IWC in 1977 to propose a ban on the aboriginals' taking of bowhead whales.[56]

At a special IWC meeting of experts on aboriginal subsistence whaling held in Seattle in 1979, the wildlife panel concluded: "In strictly biological terms, no Bering Sea bowhead whales should be hunted if the population is to have the best prospect for recovery." [57] The panel on cultural aspects noted the significant impact of such a change on the whaling communities—whaling is perhaps "the most important single element in the culture and society of north Alaskan whale hunting communities. It provides a focus for the ordering of social integration, political leadership, ceremonial activity, traditional education, personality values, and Eskimo identity." [58]

In light of the value of whaling in Eskimo life and identity and the need to preserve the endangered bowheads, for the last few years the United States has advocated allowing the Inupiats a very limited

catch.[59] At the same time, the United States has undertaken extensive research on the bowheads, including population counts. The IWC approved a quota of 18 bowheads landed or 27 struck, whichever is reached first, for 1979 and 18 landed or 26 struck for 1980.

In 1980, the National Marine Mammal Laboratory confirmed the conclusion of earlier studies that the bowhead population is expected to decline in the next century, even if no whales are taken, because of the large take of immature animals in the 1970s. The more whales that are taken, the more rapid will be the population decline.[60] At its 1980 meeting, the IWC set a 3-year quota for 1981–83 of 45 bowhead whales taken or 65 struck, with a limit of 17 taken in any one year. The United States promised that the federal government would help the Eskimos reduce the number of bowheads needed by substituting other animals for subsistence hunting and by improving the efficiency of the bowhead hunt, thus reducing the number of whales struck and lost.

CARIBOU PROTECTION

Native Alaskans depend upon caribou as well as whales for subsistence. Although caribou were once almost numberless, the population has been vastly reduced. Three of the remaining herds migrate between the United States and Canada. By far the largest is the Porcupine Herd, estimated at 90,000–120,000. The Fortymile Herd, of perhaps 4,000, is the minute remnant of the Yukon-Tanana Herd, which contained an estimated 500,000 animals as recently as 1935. The original size of the Chisana Herd is not known, but there may be only 1,000 remaining.[61] The three herds are hunted by both Alaskans and Canadians.

Concern about the caribou led to U.S.-Canadian consideration of a convention for their protection. As currently envisaged, a convention would limit annual take and provide habitat protection.

THE SEA TURTLE CONFERENCE

Six of the seven species of sea turtles are classified as threatened or endangered. A consortium of government and nongovernment organizations sponsored the World Conference on Sea Turtle Conservation in Washington, D.C., in 1979. The Conference adopted a Sea Turtle Conservation Strategy with a long-term goal of ending exploitation. Conferees agreed that highest priority should be given to stopping the leather trade, trade in stuffed juvenile turtles, collection of eggs for sale in distant markets, and trade of tortoise shells. It also recommended habitat conservation, reduced incidental catch of turtles during commercial fishing operations, and research on population and basic biology.[62]

Nesting Kemp's Ridley sea turtle, an endangered species (Stuart Porter, U.S. Fish and Wildlife Service).

BILATERAL ENVIRONMENTAL EFFORTS

CANADA

U.S. and Canadian officials, including the EPA Administrator and the Canadian Environment Minister, met several times in 1979 and 1980 on air pollution, particularly on acid precipitation. Canada is concerned about U.S. plans to accelerate the conversion of oil-fired electrical power plants to coal, fearing that acid precipitation will increase in Canada. On the other hand, the United States has been concerned about the effects of a new coal-fired power plant at Coronach, Saskatchewan, on air quality and on the quality of the Poplar River in Montana. The problem of potential water degradation from the plant has been referred to the U.S.-Canada International Joint Commission.

A report by the U.S.-Canada Research Consultation Group [63] on the long-range transport of air pollutants confirmed the large-scale movement of pollutants both within and between the two countries. The net flow of sulfur compounds is from the United States to Canada, although most of the sulfur deposited in each country is probably from domestic emissions. The total deposition in the eastern United States and Canada of sulfur in 1979 is estimated at 10 million metric tons, 4.2 million in eastern Canada and 5.8 million in the eastern United States.[64] Some 27 million metric tons of sulfur oxides were emitted from all sources in the United States in

1978.[65] Formal negotiation of an agreement to reduce transboundary air pollution is expected to begin in 1981.

MEXICO

Presidents Carter and Lopez Portillo met in September 1979 to review bilateral relations and regional and global issues.[66] They expressed interest in protecting the environment along the border and agreed that both countries should control actions that might degrade the environment on the other side. They agreed to use the U.S.-Mexican Consultative Mechanism, a system of eight U.S.-Mexican government working groups established in 1977, to reduce environmental damage. The Presidents approved a plan recommended by the International Boundary and Water Commission to solve several serious border sanitation problems.[67]

U.S. and Mexican representatives also met in Saltillo, Mexico, in September 1979 to discuss arid land management and agricultural issues. The two nations agreed to step up efforts to combat desertification and to develop a regional desertification monitoring program (desertification is discussed in Chapter 8, Human Settlements and Land Use). Collaboration is also planned in conservation of soil, water, and other resources; production of livestock and conventional crops; development of guayule, a shrub found in Mexico and the Southwest which is being cultivated as a source of rubber; and the training of Mexican nationals in forestry and agriculture.[68]

EPA officials met with their Mexican counterparts in El Paso in March 1980; the officials agreed to improve air monitoring at El Paso and Ciudad Juarez and to cooperate in controlling shipment of hazardous wastes from the United States to Mexico.[69]

In July, U.S. and Mexican officials signed a joint contingency plan on pollution of the marine environment by oil and other hazardous substances. It covers notification, containment, cleanup, and recovery and provides for designation of a joint response team to oversee the operations.[70]

ENVIRONMENTAL PLANNING IN DEVELOPING COUNTRIES

SRI LANKA AID ASSESSMENT

Before undertaking a large water resource project in the Mahaweli River Basin, the government of Sri Lanka asked the Agency for International Development (AID) to prepare a detailed environmental assessment. Sri Lanka's decision to consider environmental factors at an early stage of planning reflects increasing appreciation in developing as well as developed countries for integrating environmental and resource planning.

Three dams were to be constructed in the Basin to irrigate 340,000 acres, and roads and villages would be built to accommodate new settlers. Ten AID specialists examined in depth control of erosion and siltation, management of wildlife, and other critical environmental factors. Work on the project is now underway.[71]

UNEP CARIBBEAN ENVIRONMENTAL ACTION PLAN

Many Caribbean nations, especially the small islands, suffer serious environmental problems—uncontrolled urban and suburban growth, erosion, soil loss and deforestation, loss of economically valuable plant and animal species, extensive loss of beach sand, and oil pollution. Tourism frequently increases pressure on resources and with rapid population growth has made new demands on fragile coastal areas and habitats. Responding to requests from Caribbean countries, UNEP and the Economic Commission for Latin America, in cooperation with other UN and regional organizations, began to draft a Caribbean environmental action plan in 1976. The plan was reviewed by government representatives in Caracas in January 1980.[72]

The draft proposes strategies for conservation and sustainable use of critical resources. It focuses on coastal problems related to development, tourism, environmental health, human settlements, and alternative energy sources. Although funding for the action plan is uncertain, there was agreement on the immediate need to improve information exchange on existing environmental activities.

REFERENCES

1. Council on Environmental Quality and U.S. Department of State, *The Global 2000 Report to the President: Entering the Twenty-First Century*, Vol. One, *Summary Report* (Washington, D.C.: U.S. Government Printing Office, 1980), p. 1.
2. International Union for the Conservation of Nature and Natural Resources, *World Conservation Strategy: Living Resource Conservation for Sustainable Development* (Morges, Switzerland, 1980), Introduction.
3. The material in this section is drawn from Council on Environmental Quality and Department of State, *supra* note 1.
4. "The Environment: The President's Message to Congress," *Weekly Compilation of Presidential Documents* 13:782 (1977).
5. The White House, Statement by the President, July 24, 1980.
6. The material in this section is drawn from International Union for the Conservation of Nature and Natural Resources, *supra* note 2.
7. *Id.*, Executive Summary.
8. The material in this section is drawn from Presidential Commission on World Hunger, *Overcoming World Hunger: The Challenge Ahead* (Washington, D.C.: U.S. Government Printing Office, 1980).
9. *Id.* at 183.
10. *Ibid.*
11. Unless otherwise noted, the material in this section is drawn from U.S. Interagency Task Force on Tropical Forests, *The World's Tropical For-*

ests: A Policy, Strategy and Program for the United States (Washington, D.C.: U.S. Government Printing Office, 1980).

12. "Environmental Priorities and Programs: Message to the Congress," *Weekly Compilation of Presidential Documents* 15:1353 (1979).
13. U.S. Interagency Task Force on Tropical Forests, *supra* note 11 at 15.
14. National Academy of Sciences, National Research Council, Committee on Research Priorities, *Research Priorities in Tropical Biology* (Washington, D.C., 1980), p. 1.
15. *Id.* p. 26.
16. Norman Myers, *Conversion of Tropical Moist Forests* (Washington, D.C.: National Academy of Sciences, 1980).
17. U.S. Interagency Task Force on Tropical Forests, *supra* note 11 at 19–20.
18. *Id.* pp. 1, 19.
19. *Id.* p. 19; information provided by the U.S. Department of Agriculture.
20. Information provided by the U.S. Department of Agriculture.
21. Erik Eckholm, *Planting for the Future: Forestry for Human Needs*, Worldwatch Paper 26 (Washington, D.C.: Worldwatch Institute, 1979), p. 17.
22. U.S. Environmental Protection Agency, *Research Summary: Acid Rain*, R.D. 674 (Washington, D.C., 1979), p. 1; Council on Environmental Quality and Department of State, *supra* note 1, Vol. Two, *The Technical Report*, at 336.
23. World Meteorological Organization, *Report of the Meeting of the CAS Working Group on Atmospheric Carbon Dioxide* (Boulder, Colorado, November 1–7, 1979).
24. United Nations Environment Programme, *Report of the Interagency Meeting on Carbon Dioxide*, UNEP WG. 37/6, February 15, 1980 (Nairobi, February 14–15, 1980).
25. Report of Meeting of Experts on Chlorofluorocarbons, "Agreed Conclusions, Meeting on International Regulation of Emission of Chlorofluorocarbons" (Oslo, April 14–16, 1980), available from U.S. Environmental Protection Agency, Office of International Activities, Washington, D.C.
26. Council of the European Communities, Decision No. 80/372/EEC (Brussels, March 26, 1980).
27. U.S. Environmental Protection Agency, "EPA To Tighten U.S. Controls on Ozone-Destroying Fluorocarbons," Press Release, April 15, 1980.
28. National Academy of Sciences, Panel on Stratospheric Chemistry and Transport, *Stratospheric Ozone Depletion by Halocarbons: Chemistry and Transport* (Washington, D.C., 1979); National Academy of Sciences, Committee on Impacts of Stratospheric Changes, *Protection against Depletion of Stratospheric Ozone by Chlorofluorocarbons* (Washington, D.C., 1979).
29. National Academy of Sciences, *Stratospheric Ozone Depletion by Halocarbons: Chemistry and Transport*, *supra* note 28 at 5–6.
30. National Academy of Sciences, *Protection Against Depletion of Stratospheric Ozone by Chlorofluorocarbons*, *supra* note 28 at 6.
31. World Meteorological Organization, *Proposed Plan for the World Climate Programme 1980–1983*, WMO Publication Cg–VIII/Doc. 44 (Geneva, 1979), Appendix C.
32. United Nations Environment Programme, *Report of the Governing Council of the United Nations Environment Programme on the Work of its Eighth Session*, Decision 8/6, UNEP/GC.8/10 (Nairobi, 1980).
33. For example, International Convention for the Prevention of Pollution of the Sea by Oil, May 12, 1954, 12 U.S.T. 2989, TIAS 4900, 327 U.N.T.S. 3, amended April 11, 1962, TIAS 6109 and October 21, 1969, TIAS 8505; International Convention for the Prevention of Pollution from Ships, November 2, 1973, 12 I.L.M. 1319 (1973) and Protocol Relating to International Convention for the Prevention of Pollution

from Ships, 1973, 17 I.L.M. 546 (1978); Convention of Safety of Life at Sea, November 1, 1974, 14 I.L.M. 959 (1975) and Protocol Relating to Convention of Safety of Life at Sea, 17 I.L.M. 579 (1978).

34. The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 26 U.S.T. 2403:TIAS 8165.
35. 86 Stat. 1052, 33 U.S.C.A. 1401 *et seq.*
36. Francis X. McArdle, Commissioner, New York City Department of Environmental Protection, testimony, Oversight Hearings before the Subcommittee on Fisheries, Wildlife Conservation and the Environment and the Subcommittee on Oceanography, House Committee on Merchant Marine and Fisheries, 96th Cong., 2d sess., February 20, 1980.
37. Information provided by the U.S. Army Corps of Engineers.
38. *Ibid.*
39. *Ibid.*
40. The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, *supra* note 34.
41. International Atomic Energy Agency, "The IAEA Revised Definitions and Recommendations of 1978 Concerning Radioactive Wastes and Other Radioactive Matter Referred to in Annexes I and II to the Convention," IAEA INFCIRC/205/Add. 1/Rev. 1 (Vienna, August 1978).
42. Organization for Economic Cooperation and Development, *Decision of the Council of July 22, 1977* Document C(77)115 (Final) (Paris, August 4, 1977).
43. U.S. Department of State, Telegram 80 Paris 9749.
44. United Nations, Conference of Plenipotentiaries of the Coastal States of the Mediterranean Region for the Protection of the Mediterranean Sea Against Pollution from Land-Based Sources 1978, *Final Act* (New York, 1980).
45. Information provided by Daniel McShea, staff, *Oil Spill Intelligence Report*, Cambridge, Massachusetts.
46. Information provided by the U.S. Coast Guard.
47. U.S. Department of State, Telegram 80 Mexico 4881.
48. Protocol Relating to International Convention for the Prevention of Pollution from Ships and Protocol Relating to Convention of Safety of Life at Sea, *supra* note 33.
49. For details of the agreements, see Council on Environmental Quality, *Environmental Quality—1978: The Ninth Annual Report of the Council on Environmental Quality* (Washington, D.C.: U.S. Government Printing Office, 1978), pp. 366–68.
50. 44 Fed. Reg. 66500 (1980).
51. United Nations Environment Programme, "Report of the Working Group of Experts on its Sixth Session," Doc. No. UNEP/WG.44/CRP.20 (Paris, June 30–July 11, 1980).
52. U.S. Department of State, Office of Law of the Sea Negotiations, "Informal Composite Negotiating Text, Revision 2," 1980.
53. International Whaling Commission, *Chairman's Report of the Thirty-First Meeting* (Cambridge, England, October 1979).
54. International Whaling Commission, *Schedule* (Cambridge, England, November 1979).
55. International Whaling Commission, Meeting on Aboriginal/Subsistence Whaling, Report of the Wildlife Panel, "Bowhead Whaling: Population Status and Alternative Biological Resources" (Seattle, February 5–9, 1979), pp. 1–2.
56. International Whaling Commission, *Report of the 29th Meeting* (London, 1977).
57. International Whaling Commission, *supra* note 55 at 19.
58. International Whaling Commission, Meeting on Aboriginal/Subsistence Whaling, "Report of the Panel to Consider Cultural Aspects of Aboriginal Whaling in North Alaska" (Seattle, February 5–9, 1979), p. 3.

59. National and Oceanic and Atmospheric Administration, National Marine Fisheries Service, "The United States Conservation Program for Bowhead Whale (*Balaena Mysticetus*) in the Bering, Chukchi, and Beaufort Seas" (Washington, D.C., November 15, 1977).
60. Howard P. Braham and Jeffrey M. Breiwick, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, National Marine Mammal Laboratory, *Projections of a Decline in the Western Arctic Population of Bowhead Whales* (Seattle, June 1980).
61. U.S. Department of State, environmental impact statement, "Proposed Convention for the Conservation of Migratory Caribou and Their Environment" (draft, 1980), pp. 20–26.
62. World Conference on Sea Turtle Conservation, *Sea Turtle Conservation Strategy* (Washington, D.C., November 30, 1979).
63. U.S.-Canada Research Consultation Group on the Long-Range Transport of Air Pollutants, "The LRTAP Problem in North America: A Preliminary Overview" (Washington, D.C., and Ottawa, Canada, 1979).
64. *Id.* p. 13.
65. U.S. Environmental Protection Agency, *National Pollutant Emission Estimates 1970–1978*, EPA–450/4–80–002 (Washington, D.C., 1980), Table 1, p. 2.
66. The White House, Joint Press Statement, September 29, 1979.
67. International Boundary and Water Commission, United States and Mexico, *Recommendations for the Solution to the Border Sanitation Problems*, Minute No. 261, U.S. Department of State TS–9658 (Washington, D.C., September 24, 1979).
68. U.S. Department of State, Telegram 79 Mexico 15938, September 17, 1979.
69. U.S. Department of State, Telegram 80 Mexico 4420, March 14, 1980.
70. Agreement of Cooperation between the United States of America and the United Mexican States Regarding Pollution of the Marine Environment by Discharges of Hydrocarbons and Other Hazardous Substances, July 24, 1980.
71. Information provided by the Agency for International Development.
72. United Nations Economic and Social Council, Economic Commission for Latin America, Meeting of Government-Nominated Experts To Review the Draft Action Plan for the Wider Caribbean Region, *Report*, Document No. E/CEPAL/PROY. 3/L,6, April 1980 (Caracas, January 28–February 1, 1980).

Chapter 2

ECOLOGY AND LIVING RESOURCES—BIOLOGICAL DIVERSITY

In 1741, the crew of a Russian ship discovered strange sea creatures around the fog-shrouded Komandorskyi Islands in the Bering Sea. Unlike seals or whales, the gigantic (10-ton) cowlike mammals grazed upon lush growths of algae. To relieve their boring diets, the men killed the creatures for food. Other ships followed, the killing continued, and by 1768, the newly discovered Steller's sea cow (*Hydrodamalas gigas*) was extinct.[1]

Rather than being an isolated incident, extinction—the death of species—is increasing. From 1600 to 1900, approximately 75 mammal and bird species went the way of the dodo at a rate of 1 every 4 years. From 1900 to the present, about 75 more vanished—nearly one each year.[2] But mammals and birds are the best studied of organisms. A list of known extinctions in the United States[3] suggests that they comprise only a small fraction of the total because extinctions in less-known but more diverse groups (e.g., fishes, insects) are probably underestimated, and plants, microorganisms, and marine species (other than mammals and birds) are not included at all. Some biologists estimate that one to three extinctions are now occurring daily and that the rate will increase to one per hour by the late 1980s. Of the 5–10 million species in existence worldwide, most of which have never even been named, much less studied, at least one million are likely to be lost within our lifetimes.[4] Rapid species loss on such a scale would be unprecedented in the last 65 million years[5] or, conceivably, since the beginning of life on this planet.

In a world filled with pressing problems, one may ask why the loss of a million species should be considered an unparalleled tragedy. Surely there is enough human misery to occupy a legion of Albert Schweitzers; why should not all efforts focus on our own species? A basic answer is that by reducing biological diversity, humanity is squandering its greatest natural resource, on which we depend for food, oxygen, clean water, energy, building materials, clothes, medicines, psychological well-being, and countless other benefits.

The recent discovery of a tall, undistinguished-looking plant illus-

trates just how valuable some species are. *Zea diploperennis*, one of several Mexican grasses called teosinte, is very closely related to corn, *Z. mays*, and can be crossbred with it. But corn is an annual that must be replanted after every harvest, whereas *Z. diploperennis* is a perennial that grows from rhizomes (underground stems). If perennial corn varieties could be developed, they might greatly reduce the major corn production costs of plowing under stubble and sowing seed one or more times per year. This and other traits, such as virus resistance or ability to grow in wet soils, could increase the value of corn gene pools by billions of dollars. Yet *Z. diploperennis* might easily have become extinct before it was discovered. Only a few thousand of these plants exist, occupying three minute sites in an isolated mountain range now being developed.[6] A bulldozer could have destroyed them all in an hour. It will never be known how many other multibillion dollar plants will be clearcut, paved over, plowed under, nibbled by goats, or poisoned into extinction before their value is recognized.

With uniquely developed abilities to fashion tools and disseminate information across continents and generations, humans have come to dominate the planet. People and institutions now face choices of how to use this unprecedented power, including whether to allow or seek to avoid the disappearance of species. It is increasingly clear that humankind is tied to other species—that most biological extinctions and human misery have the same causes and must be treated as inseparable parts of the same global ecosystem.

This chapter discusses why biological diversity is essential, how people can cause and prevent extinctions, and what federal programs have the potential to slow the elimination of species.

MATERIAL BENEFITS OF BIOLOGICAL DIVERSITY

Biological diversity includes two related concepts, genetic diversity and ecological diversity. Genetic diversity is the amount of genetic variability among individuals in a single species, whether the species exists as a single interbreeding group or as a number of populations, strains, breeds, races, or subspecies. Ecological diversity (species richness) is the number of species in a community of organisms. Both kinds of diversity are fundamental to the functioning of ecological systems.

THE ROLE OF BIOLOGICAL DIVERSITY

In the natural world, organisms are challenged by physical and chemical fluctuations, predation, parasitism, and competition for resources. An organism's ability to withstand these challenges is largely determined by its genetic makeup. Throughout the biosphere—the thin film of air, land, fresh water, and sea that supports life on this

planet—there are one or more genetically distinct species and one or more genetic patterns (genotypes) within each species that can survive given environmental challenges. More successful individuals tend to have more surviving young, thus passing on more of their genes to the next generation. Others just get by, leaving few descendants. Individuals with the least suitable genetic patterns either die or fail to produce viable offspring. The differing degrees of reproductive success among the diverse genotypes change the genetic composition of the population over time, a process called evolution. As evolution proceeds, new combinations of genes allow adaptations to the environment. As the climate changes, plants may develop smaller, thicker leaves which lose water more slowly, and as disease organisms evolve, other organisms may evolve chemical defense mechanisms which confer disease resistance.

If the physicochemical (nonliving) and biological environments posed no uncertainties, evolution by natural selection might eventually stop as surviving species would come to consist entirely of "optimal" genotypes. But the fossil and historical records show that change is certain to occur, and the genetic patterns ideal for the rigors of one time and place are unlikely to be ideal for others. Further, populations adapt to local conditions. Although it is not difficult to imagine how the genetic makeup of the puma (*Felis concolor*) might vary throughout its patchy distribution from Canada to Argentina, genetic patterns in some species differ within a few yards[7] or in a single season.[8]

Genetic diversity has evolved because it maximizes the likelihood that at least some individuals of a species will withstand environmental change.[9] If it is lost—as occurs when humans reduce natural populations to very low levels[10] or excessively inbreed agricultural species—the risk of extinction or crop failure rises markedly.

This genetic diversity, which is critical to species survival in the natural world, is also essential to the development of new crops and livestock. For example, disease-resistant barley (*Hordeum vulgare*) has been developed by crossbreeding primitive barley varieties with newer varieties and by subsequent artificial selection.[11]

If genetic diversity within species is valuable to people, ecological diversity is even more so, because genetic variation among species is greater than within species. Each species in a community is a unique genetic solution to a combination of environmental challenges. Under any given circumstance, some solutions are better than others. This fact is reflected in differing abundances of species in nature—most communities are composed of a few abundant species and many less common ones. But it does not imply that rare species such as snail darters (*Percina tanasi*) or Furbish louseworts (*Pedicularis furbishiae*) are losers that can be written off without concern. A narrowly or sparsely distributed species may be a keystone species in its community (a species that controls the structure and functioning in its community, e.g., the sea otter, *Enhydra lutris*),[12] or it may

possess characteristics valuable to humans (e.g., *Zea diploperennis* as mentioned above). People existed several million years before the 1970 discovery that blood cells from the bizarre horseshoe crab *Limulus polyphemus* could be used to improve testing for bacterial endotoxin.[13] No one can predict which species will provide valuable material benefits in years to come. In natural biological diversity, humankind has varied, infinitely renewable supplies of food, energy, industrial chemicals, and medicines.

NEW SOURCES OF FOOD

In the next 20 years, the human population is expected to swell nearly 50 percent[14] and, in some of the poorest countries, nearly 100 percent.[15] Demands on living resources will increase rapidly. To avoid worldwide deterioration of the human condition, food yields in traditionally harvested lands and waters must keep pace or new areas must come into production. Neither alternative will be readily accomplished. With present agricultural practices, increases in yield per acre are ever more costly, even where productivity of the land is maintained.[16] Too often it is not—because of desertification, salination, erosion, urbanization, or pollution.

By the year 2000, the acreage of traditional crops under cultivation may well increase no more than 4 percent because most arable land is already under cultivation.[17] Producing on marginal lands is very costly. Risk of crop failure, even on prime farmland, increases as nations rely on fewer, more inbred crop strains. Further, agriculture that depends heavily on fossil fuels for machinery, fertilizer, and pesticides can be crippled by fuel shortages and price increases. In coming decades, employment of the earth's reservoir of biological diversity to increase yields and develop new and pest-resistant crops is essential to the billions of humans who need to be fed.

There are several methods for developing crops with new characteristics: select for desirable traits in conventional crops (sufficient genetic variability generally exists where traditional varieties have not been replaced by genetically uniform varieties), introduce genes into conventional crops by crossbreeding with closely related wild species, identify organisms that can yield new kinds of crops, and use gene-splicing techniques, a method with great potential. Biological diversity is essential for all these methods.

One of the most serious global agricultural problems is the shortage of fresh water. Although saline water may be readily available, fresh water supplies are inadequate to support existing commercial grain varieties in an increasing proportion of the land. Scientists examining 7,200 barley genotypes found that some can grow in sand irrigated with sea water, with yields that are at least one-half the average yield per acre worldwide.[18] The same team crossed the commercial tomato (*Lycopersicon esculentum*), which lacks salt-tolerant genes, with an inedible but salt-tolerant wild tomato, *L. cheesmanii*,

from the Galapagos Islands to obtain uniform (and reportedly delicious) fruit irrigated with 70 percent sea water.

Many wild or traditionally cultivated plants and animals are promising sources for improving nutrition in developing nations. The Asian winged bean, *Psophocarpus tetragonolobus*, has exceptionally high levels of high lysine protein in its seeds, pods, leaves, and tuberous roots and could be farmed throughout the wet tropics, where few edible legumes can be grown.[19] The widespread estuarine-lagoonal seagrass *Zostera marina*, which has provided wheat-like grain to the Seri Indians of Baja California for centuries,[20] could supplement food supplies in subtropical coastal regions.

Substituting indigenous species which are adapted to local conditions for nonnative species can increase yields substantially. Meat production from native grazers, such as wildebeest (*Connochaetes* spp.) is considerably higher than from cattle and sheep introduced on East African ranges.[21] Similarly, cattle-bison hybrids reach market size twice as fast as purebred cattle on U.S. rangeland.[22] Conversely, under stringently administered biological control programs, nonnative species can aid food production in the absence of comparable native species. A parasitic Indian wasp, *Pediobius foveolatus*, shows considerable promise for controlling the Mexican bean beetle, *Epilachna varivestis*, a serious pest of legumes in the United States.[23]

NEW SOURCES OF ENERGY

Biological diversity shows increasing potential for meeting world energy needs. Except for the present temporary Fossil Fuel Age, most world energy resources have been renewable. With the depletion of fossil fuels, organisms that can produce energy-rich materials are increasingly attractive.

Many plant species produce hydrocarbon-rich latex, which may be used as fuel, including some *Euphorbia* spp. and milkweeds (*Asclepias* spp.).[24] Giant kelp (*Macrocystis pyrifera*), a fast-growing cool-water seaweed, can yield methane for industrial and cooking gas. Microbes in the gut of the endangered green sea turtle, *Chelonia mydas*, generate hydrogen gas from vegetable materials;[25] perhaps some day these microbes could be grown on agricultural wastes. Another potential source of hydrogen (and of nitrogen fertilizer) is the blue-green alga, *Anabaena azollae*, which lives in *Azolla pinnata*, a tiny tropical fresh water fern.[26] A more conventional source of energy, but one with considerable potential for tropical-subtropical less developed countries (LDCs), is fuelwood from *Leucaena leucocephala*, a fast-growing tropical leguminous tree that also increases nitrogen levels in the soil.[27] (See Chapter 6, Energy, for discussion of biomass as an energy source and hydrogen as an energy carrier.)

The new sources of energy will not be a global panacea. If vast tracts of prime farmland, desert, or tropical forest were converted to fuel plantations, the net result could be more harm than good.[28]

But balanced, efficient combinations of production and recycling systems using previously unused living resources could fulfill some of the most pressing human needs.

NEW SOURCES OF INDUSTRIAL CHEMICALS AND RAW MATERIALS

Although laboratory synthesis of urea in 1828 ended humankind's exclusive dependence on natural sources of organic chemicals, many raw materials are derived from organisms—from free-ranging marine fishes (e.g., menhaden, *Brevoortia* spp., a source of oils) to intensively managed trees (e.g., slash pine, *Pinus elliotti*, a source of paper pulp). Other organic raw materials are derived from nonrenewable coal and hydrocarbons, which are the chemically altered remains of ancient plants and animals. As the human population increases and fossil fuels are depleted, the demand for renewable raw materials will increase. Biological diversity can provide many of them.

One of these materials is rubber. Most rubber is made from petroleum or from the latex of the Amazonian rubber tree (*Hevea brasiliensis*). Rubber demand is rising sharply; as a result, Mexico and the United States are developing domestic rubber industries based on guayule (*Parthenium argentatum*), a native desert plant.[29]

Liquid waxes, whose only commercial source was the sperm whale, *Physeter catodon*, are unexcelled lubricants at high temperatures and pressures. But the seeds of a desert bush, the jojoba (*Simmondsia chinensis*), have been found to be rich in liquid wax. Jojoba research

Harvesting jojoba in Bilat, Israel. This arid land crop's seeds contain a liquid wax that could replace industrial use of sperm whale oil (M. Forti, National Academy of Sciences).

and development are advancing rapidly in Israel and the United States, and jojoba farming could be an economically attractive alternative to the killing of sperm whales.[30]

Another renewable raw material is paper pulp. Most U.S. paper is manufactured from conifers which can be harvested at about 15 years. An alternative may be kenaf (*Hibiscus cannabinus*), a fast-growing plant from Kenya and Tanzania, which produces long fibers suitable for newsprint and other kinds of paper and which can be cropped annually even in northern latitudes.[31]

Tannins have industrial uses ranging from leather-making to oil and gas drilling. Nearly all U.S. industrial tannins are imported, but smooth sumac (*Rhus glabra*), a native shrubby tree, is a rich source of tannin. After it develops adequate root carbohydrate reserves, smooth sumac can be harvested twice each year, with annual tannin yields valued at about $800 per acre. This sumac also produces industrial oils, hydrocarbons of potential use as fuel, and protein of potential use as animal feed.[32]

NEW SOURCES OF MEDICINES

Species are genetically distinct, and because genes control cellular production of biochemicals, living things are chemically diverse. Since prehistoric times, people have exploited this chemical diversity to alleviate illness. Many wild herbs used in folk medicine contain pharmacologically active chemicals, and almost one-half the prescriptions in the United States contain ingredients of natural origin.[33]

Organisms are not equally likely to possess chemicals of pharmaceutical value. In ecosystems with long histories of low physicochemical stress, pressures from predators, parasites, and competitors are high.[34] Many organisms have responded by evolving the means to produce biochemicals to thwart others that would eat, invade, or overgrow them.[35] Pharmacologically interesting chemicals are most common in species-rich communities, especially tropical coral reefs[36] and moist forests.[37] Plants, fungi, insects, and sessile marine invertebrates lacking physical means to avoid or deter predators and competitors are especially rich sources.

Some of these chemicals (e.g., antibiotics such as penicillin and erythromycin) are more toxic to bacterial cells than to human cells. Others kill or inhibit cancer cells but cause less damage to healthy human cells.

The National Cancer Institute (NCI) has screened 25,000–35,000 higher plant species for activity against one or more types of cancer.[38] As of July 1977, 2,591 species had shown reproducible activity, but only a small fraction has all the necessary characteristics for clinical trials. Maytensine, from a Kenyan plant, and bruceantin, from an Ethiopian tree, are among the chemicals from tropical plants now undergoing clinical trials. North temperate forest plants have contributed taxol (from yews, *Taxus* spp.) and VM–26 (from may-

apples, *Podophyllum* spp.). The NCI is also screening chemicals from microbial fermentation and from marine animals. Extracts from more than 500 species of marine animals are known to have anticancer activity. Marine organisms are considered a virtually untapped source of new chemicals for the study and treatment of disease.

THE PSYCHOLOGICAL AND PHILOSOPHICAL BASIS FOR PRESERVING BIOLOGICAL DIVERSITY

Paleontology and cell and molecular biology suggest that living things shared a single origin at least 3.5 billion years ago. Perhaps this ancient kinship explains why it is essential to the psychological well-being of so many people to collect, hunt, read about, watch, photograph, or be surrounded by diverse living things. There would be little excitement in only one kind of flower, bird, or butterfly; their fascination lies in their different sizes, shapes, colors, sounds, behaviors and abundances, their complexity, and their freedom. The skyrocketing attendance figures for national parks; increasing participation in backpacking, skin diving, and cross-country skiing; rapidly proliferating urban gardens; and population shifts to rural areas suggest that experiencing diverse living things fulfills deep-seated human needs.

The relationships of human beings and nature have long been major themes explored by scientists, artists, philosophers, and religious figures in both eastern and western cultures. Their views span a spectrum from emphasis on the utilitarian benefits of conserving living things as natural resources to emphasis on the ethics of maintaining biological diversity. These views have formed the bases of public conservation programs and are fundamental to the resolution of the environmental dilemma that humankind now faces.

Humankind is both a part of nature and a transcendant species with unparalleled abilities. The powerful drives for self-preservation and perpetuation unite all living things. But the predominant or only way that other species can perpetuate themselves beyond their individual lifetimes is by reproduction, passing on their genes. Humans have made quantum advances over other species in developing a second approach to self-perpetuation: bequeathing information and values as art, science, literature, language, legends, or laws to future generations. Culture, the learned and shared nongenetic system of values, behavior, and knowledge, gives humans an ability to control the earth that is unmatched. What our species does with this power depends on our definition of self.

At one extreme is the philosophy which holds the most limited self-definition—"the world begins when I open my eyes and ends when I close them; I am all that is." Some definitions of self extend to families and tribes, as evidenced by the widespread independent

synonymy of the particular tribal name and the word for "human" in languages of many tribal peoples. Ethnocentricity and nationalism are the extensions of self to comprise one's ethnic group or nation. The Biblical commandment "Love thy neighbor as thy self" equates self to all humans. The Hindu and Buddhist prohibitions against eating meat extend self-definitions to include all animal life. Perhaps the ultimate extension of self is pantheism, whose adherents equate the natural components and laws of the universe with God.

The positions of people and institutions along this continuum affect all their actions, including their willingness to accept various arguments for the preservation of biological diversity. Those adhering to the first several self-definitions will be persuaded only by utilitarian arguments, that destroying species will harm the decision-makers or their biological or intellectual progeny. Some utilitarians saw the snail darter-Tellico Dam controversy as the simple choice between a +$100 million dam and a fish population that, collectively battered and deep-fried, might fetch less than one millionth as much. A more comprehensive utilitarian view might have pointed to the as-yet unknown values of the fish for humankind (a unique ecological insight or a biochemical that could cure a terrible disease). In the end, neither this argument nor those on other grounds dissuaded proponents of the Dam.

The difficulty with basing species preservation on short-term economic value was forcefully stated by the forester-wildlife ecologist Aldo Leopold in "The Land Ethic":

> Of the 22,000 higher plants and animals native to Wisconsin, it is doubtful whether more than 5 percent can be sold, fed, eaten, or otherwise put to economic use. Yet these creatures are members of the biotic community, and if (as I believe) its stability depends on its integrity, they are entitled to continuance.[39]

It is quite possible that some species will yield utilitarian benefits so small or so far in the future that all but the most farsighted utilitarians will be willing to dispense with them. David Ehrenfeld, a contemporary ecologist, physician, and philosopher, observes that those who wish to prevent the extinction of species often portray them as resources, which he defines "very narrowly as reserves of commodities that have an appreciable money value to people, whether directly or indirectly." He suggests that the endangered Houston toad, *Bufo houstonensis,* is an exemplary "nonresource," because it "has no demonstrated or even conjectured resource value to man."[40] In fact, this particular example may not support his contention. All toads have toxic skin secretions. Chemicals such as bufadienolides,[41] which could someday be important drugs, were discovered in other *Bufo* species, and the Houston toad could be a particularly good source. But the idea that some species are nonresources is nonetheless correct. The short-term material benefits of many species may be extremely small. Arguments for species preservation based on economic values of each and every species will not convince many people who reckon values only in the short term.

Yet a substantial number of people would argue on philosophical grounds that all species should be preserved.[42] Indeed, public policies to protect biological diversity, like policies to protect many human values, reflect cultural and religious concepts that extend the definition of self to include nonhuman life. Since the late 19th century, conservation legislation has grown from the ethical and philosophical concepts of life proposed by John Muir, Aldo Leopold, Rachel Carson, and others. Utilitarianism alone did not motivate the political actions culminating in the Wilderness Act,[43] the Endangered Species Act,[44] or even the National Environmental Policy Act.[45] As one of the pioneers of the science of ecology, Charles S. Elton said:

> The first [reason for conservation], which is not usually put first, is really religious. There are some millions of people in the world who think that animals have a right to exist and be left alone, or at any rate that they should not be persecuted or made extinct as species. Some people will believe this even when it is quite dangerous to themselves.[46]

Or, as David Ehrenfeld stated,

> This non-humanistic value of communities and species is the simplest of all to state: they should be conserved because they exist and because this existence itself is but the present expression of a continuing historical process of immense antiquity and majesty.[47]

But utilitarian views do not necessarily conflict with the preservation of species for their own sake. As was true of Socrates—who was acclaimed the wisest of his time, yet said he was only wise enough to know how much he did not know—our wisest contemporaries are those willing to admit the enormity of what is not yet known. The discovery of the utilitarian values of the vast majority of species will lie in the future, if humankind allows them a future. Aldo Leopold expressed this idea in "The Round River":

> If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.[48]

HUMAN REDUCTION OF BIOLOGICAL DIVERSITY

A NEW SPECIES AND ITS INFLUENCES

Just when people need the productivity and diversity of the biosphere as never before—and have painstakingly begun to comprehend its many benefits—we threaten to decimate the earth's species. In nearly all cases, the losses will be unintentional.

Every organism affects its contemporaries and those that follow. Sometimes one species dominates the lives of others. Camouflage, sharp thorns, and chemical deterrents to predators evidence the intense, largely unexplored interactions among species. At other times, the influence of one individual or species seems infinitesimally small, often undetectable to the limited senses, instruments, and under-

standing of humankind. Indeed, an observer of the shrew-like creature that moved nimbly through the twilit branches would not have guessed that 60 million years hence, *its* descendants, a species that calls itself *Homo sapiens* (wise man), would be a million times more abundant than the visible stars and would change the very face of the earth.

The first humans affected the biosphere but little. They foraged for roots, fruits, insects, small vertebrates, and the occasional bonanza of a dead or dying mammal that the scavenging jackals and vultures had missed. As their evolving populations crept upward in number and ingenuity, they sequestered and then made fire to drive larger, fleeter, or more ferocious beasts before them. Giant ground sloths, mammoths, and sabre-toothed tigers in North America withstood repeated Pleistocene glacial advances (ice ages) and retreats only to be hunted to extinction by human invaders from Asia. Indeed, the last North American elephant, the American mastodon (*Mammut americanus*), survived until a few thousand years ago.

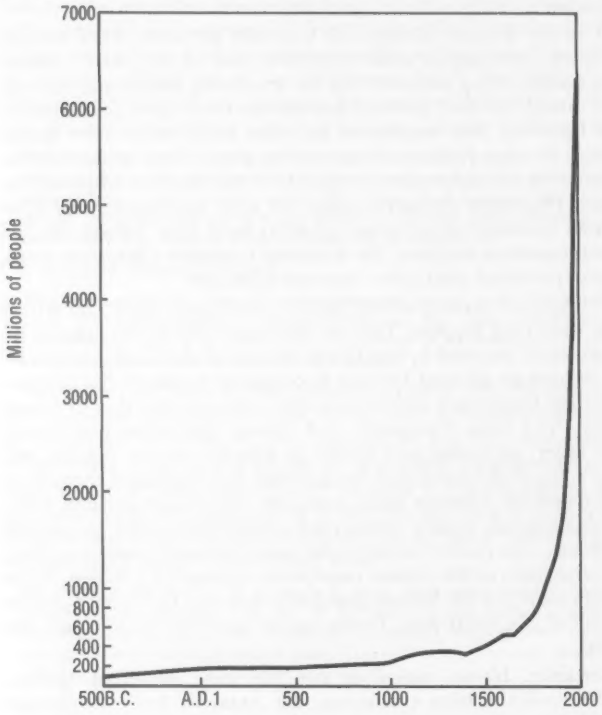
When game became scarce, humans sowed grass seeds and settled near their food supplies. Written languages allowed the transfer of information acquired by one to tens or tens of thousands. Accelerating technology allowed humans to overcome or ignore the progressively less threatening and less common creatures that they had once feared. The tools, discoveries, and human population proliferated ever faster, perturbed only briefly by episodic famine, plague, and war. Some of the remaining living things accommodated themselves to humankind, infesting fields, granaries, sewers, and clothing. Others disappeared, usually unrecorded, occasionally noted by natural historians. The pace of scientific discovery and social change accelerates dizzyingly as the human population approaches 5 billion. (The growth curve for the human population is shown in Figure 2–1.) In a wink of geological time, *Homo sapiens* has come to dominate the earth.

Certainly, *Homo sapiens* is not the most numerous species. A shrimp-like marine crustacean, the Antarctic krill (*Euphausia superba*) may be many times more abundant. Nor is *H. sapiens* the first species to modify its environment. But beavers, woodpeckers, and skunks alter their environments far less than irrigation projects, construction, and air pollution. Human evolution has taken unique pathways. With the conceivable exception of some dolphins and larger whales, human ability to learn is unmatched. Although behavior in other species is largely "hardwired" (inflexibly determined by genes), a human is far more programmable, able to learn from both personal experience and the experience of others. The manipulative abilities of human hands are hardly less remarkable. And as a pinnacle of social evolution,[49] the concerted efforts of human minds and hands allow achievements far surpassing those of like numbers working independently.

The opportunities for such an intelligent, manipulative, social

Figure 2-1

World Population Growth, 500 B.C.-A.D. 2000



Sources: C. McEvedy and R. Jones, *Atlas of World Population History* (New York: Penguin Books, 1978), p. 342; U.S. Bureau of the Census, *Current Population Reports* (Washington, D.C.: U.S. Government Printing Office, 1980), pp. 23, 79.

creature with a population of 4.5 billion are staggering. Yet without intending to do so, the human species is destroying other heirs to the adjusting, perfecting process of evolution because they cannot keep up with the rapidly increasing changes that people cause. All but the most adaptable weedy species will falter unless people provide for and protect "our only [known] living companions in the universe."[50]

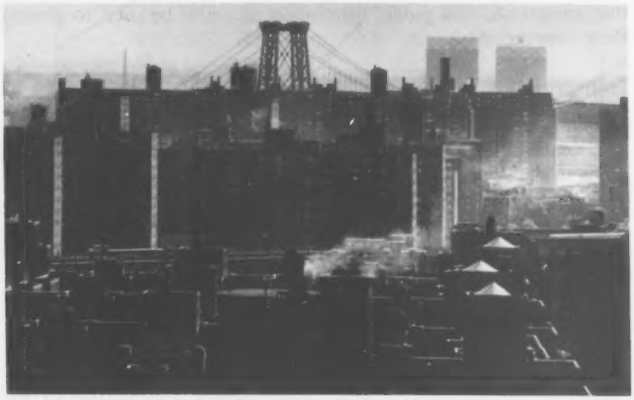
This section examines some ways that people reduce biological diversity by modifying the land and sea, disposing of chemical wastes, killing plants and animals directly, and subjecting them to new predators, diseases, and competitors.

LAND AND SEA USE

Although 10,000 years ago hunting was the major human environmental impact, the greatest threat to biological diversity today is habitat modification. Few people realize that the bulldozer is a far more effecive agent of extinction than the gun. Land use that diminishes biological diversity includes human settlements, transportation, food production, and forestry.

Human Settlements

Unless people come to accept increasingly crowded living arrangements, the number of dwelling units worldwide will have to double every 35 years to accommodate population growth at current rates. Yet every house, road, shopping center, commercial building, and parking lot is built on land once occupied by natural communities of organisms. Construction along coastlines and lake shores, on bar-



New York City. Urban ecosystems are rapidly displacing natural and agricultural ecosystems throughout the world (Elliott A. Norse).

rier islands, and in river valleys can be particularly damaging to ecologically diverse communities. Human settlements also have indirect impacts. The southwestern streams and springs now diverted for farms, swimming pools, and lawns were once homes for such species as the endangered Gila trout (*Salmo gilae*) and the extinct Shoshone pupfish (*Cyprinodon nevadensis shoshone*).

In Florida and other coastal areas, tidal marsh and mangrove wetlands that provide nursery grounds for fishes and export food to adjacent coastal waters[51] are being destroyed by construction of finger-fill canals to accommodate recreational boats. In contrast to the ebullient productivity of natural tidal channels, stagnation impoverishes finger-fill canals.[52] Proponents of this and many other kinds of

development often maintain that the fishes, waterfowl, mammals, and other wildlife will not be killed—that they will go elsewhere. The assumption is that the habitats to which wildlife might flee will be below carrying capacity, i.e., that the new habitats will have surpluses of the species' particular food, shelter, and other requirements. But this assumption is nearly always wrong, and there is nowhere for displaced wildlife to go.

Housing development in prime wildlife habitat is driven by the increasing population and rates of household formation, lower prices away from population centers, and the human desire to avoid crowding and to seek the amenities of rural life and the natural environment.[53] Often human settlements destroy the amenities being sought, although imaginative, far-sighted land use planning can direct needed growth away from critical natural areas. A variety of planning and regulatory techniques, particularly at the local level, can be combined with federal and state tax incentives to create cluster development and protect open space. Regulation, private conservation easements, and public acquisition can also be used to protect these ecosystems.

Transportation

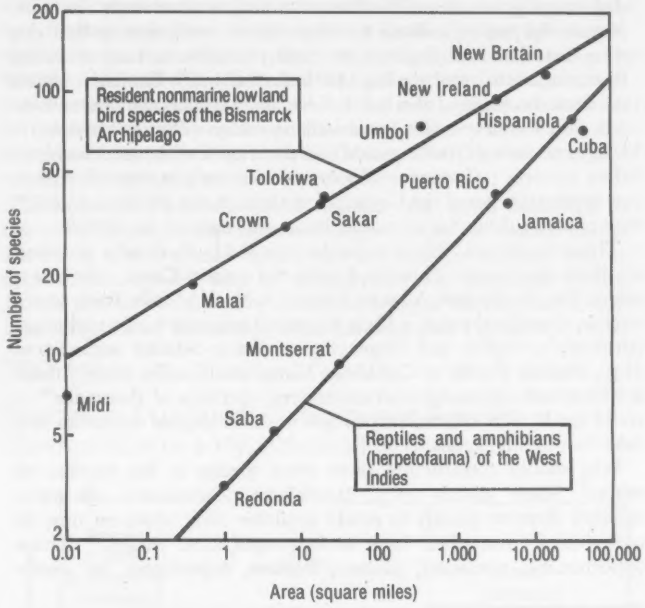
Building roads, canals, railroads, and pipelines degrades or destroys natural communities and changes drainage patterns that took aeons to develop. A less obvious impact of such linear development is the division of continuous ecosystems into islands.

Islands in oceans have fascinated ecologists since the mid-1800s, when the insights of Wallace and Darwin led to the beginnings of modern evolutionary theory. More recently, two visionary ecologists, Robert MacArthur and E.O. Wilson, synthesized disparate bits of theory and information into a predictive theory of island biogeography.[54] They found that, other things being equal, large islands accommodate larger numbers of land-dwelling species than small islands, as shown in Figure 2–2. This tendency proved true for inhabitants of other kinds of ecologically isolated islands—alpine mammals on mountaintops,[55] birds in woodlots,[56] fishes in lakes,[57] mites in isolated "cushion" plants,[58] marine worms in artificial sponges,[59] and even protozoans in the intestines of monkeys.[60] The same tendency should prove true for other inhabitants of natural environments fragmented by the crisscrossing of roads, powerlines, and canals.

When large ecosystems become smaller (e.g., when waters in an impoundment convert hills to islands), the number of species always declines[61] toward a new equilibrium for many reasons. Some animal species (e.g., rabbits) feed upon common, small, rather evenly distributed food items; others, particularly large carnivores (e.g., wolves) require large food items, which are almost always rarer. Large species may be left with insufficient food during all or part of the year by chance alone. Fragmentation may produce islands too

Figure 2-2

Relationship between Number of Species and Island Size



Sources: For reptiles and amphibians, R.H. MacArthur and E.O. Wilson, *The Theory of Island Biogeography* (Princeton, N.J.: Princeton University Press, 1967), Figure 2, p. 8 (copyright © 1967 by Princeton University Press; Princeton Paperback, 1967); for bird species, Jared M. Diamond, *The Island Dilemma: Lessons of Modern Biogeographic Studies for the Design of Natural Reserves* (London: Applied Science Publishers Ltd., 1975), p. 131 (copyright © by Allied Science Publishers Ltd.).

small to support the minimum population necessary for reproduction. Or reproduction may occur, but with the limited number of genes in small numbers of parents, there may be problems associated with inbreeding.[62] Fluctuations may bring small populations below the point at which recovery is possible. If a habitat island shrinks rapidly, the most motile inhabitants may retreat to less-altered areas, precipitously increasing the demand for food and lowering the chance that any of the competitors for it will survive.

For good dispersers, roads may not act as barriers, but surprisingly large numbers of species are vulnerable because they do not disperse well.[63] No bird species that disappeared from Barro Colorado Island after it was created by rising waters in the Panama Canal's Gatun

Lake ever reestablished on the Island, although mainland populations are only about 500 meters (547 yards) away.[64] Even narrow roads cut through closed tropical forests can stop bird dispersal,[65] in effect creating islands. As a result, the number of species originally inhabiting a given area of land tends to decline after roads are built.

Ironically, roads facilitate the dispersal of weedy species that can utilize disturbed bushy, grassy, or marshy conditions, such as kudzu (*Pueraria lobata*) and starlings (*Sturnus vulgaris*). Similarly, canals that crisscross parts of the South have aided dispersal of water hyacinth (*Eichornia crassipes)* and walking catfish (*Clarias batrachus*). Weedy species can render roads and drainage canals uneconomical. When alewives (*Alosa pseudoharengus*) and sea lampreys (*Petromyzon marinus*) entered the Great Lakes through the Welland Canal,[66] they caused substantial economic losses and damage to wildlife.

These detrimental effects could be dwarfed by those of a proposed sea-level canal across Panama. Unlike the present Canal, which separates the Pacific and Atlantic Oceans with a 50-mile fresh water barrier, a sea-level canal is likely to permit two-way biotic exchange. Although ecologists and biogeographers have debated some issues (e.g., whether Pacific or Caribbean biotas would suffer more), there is widespread agreement that extinctions—perhaps of thousands[67]—could result, with substantial changes in the ecological dynamics and fisheries of both oceans.

Why should construction favor some species at the expense of others? Some species (e.g., dandelions, *Taraxacum officinale;* rabbits) disperse quickly to newly available sites, waste no time in reproducing, and often have wide geographical ranges.[68] These opportunistic, r-selected, pioneer, fugitive, supertramp, or weedy

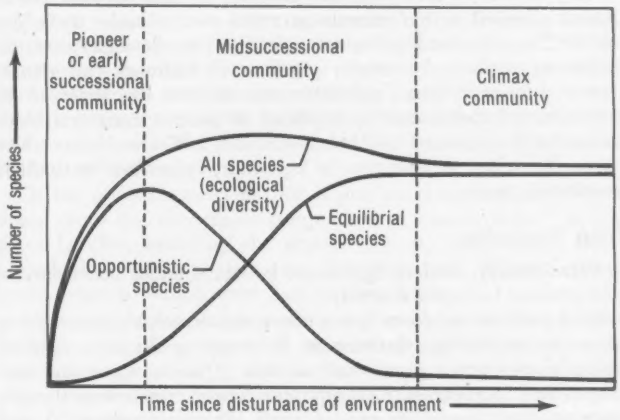
Mating houseflies (*Musca domestica*), an abundant opportunistic species with rapid reproduction and broad food requirements (Elliott A. Norse). Everglades kite (*Rostrhamus sociabilis*), an endangered equilibrial species that reproduces slowly and feeds on only one species of snail whose population is also declining. (Luther Goldman, U.S. Bureau of Sport Fisheries and Wildlife)

species, as they are variously called, usually fare poorly in undisturbed ecosystems. In contrast, equilibrial, K-selected, climax, or high S species (e.g., redwood trees, *Sequoia sempervirens;* bighorn sheep, *Ovis canadensis*) disperse to newly available areas, grow, and reach reproductive age more slowly. Many have highly specialized feeding or habitat requirements or limited geographic ranges, and some are rare wherever they occur. Their main advantage is that they are well-adapted to deal with other species as long as their environments are unchanging. All but the most ephemeral or stressful ecosystems probably have species at many points along the opportunistic-equilibrial continuum, but equilibrial species comprise a larger fraction of the biota in stable ecosystems.

Disturbed and newly available habitats (e.g., areas deforested by fire or bulldozers, newly deposited badger mounds or coastal barrier islands, or freshly grazed coral rock) are usually colonized first by opportunistic species, then by successively more equilibrial species. If this process of succession continues without disturbance, a self-sustaining climax community often develops (see Figure 2–3). Spe-

Figure 2-3

Change in Ecological Diversity and Species Composition in a Hypothetical Ecosystem



Source: Adapted from F.H. Bormann and G.E. Likens, *Pattern and Process in a Forested Ecosystem* (New York: Springer-Verlag, 1979), p. 119.

cies richness increases until or sometimes shortly before climax is reached, food webs become more complex, and the transfer of energy and the cycling of materials tend to become more efficient. When roads or pipelines are cut through natural ecosystems, equilibrial

species generally suffer disproportionately, and communities revert to earlier, less-diverse successional stages that are dominated by opportunists.[69]

Linear construction is not the only transportation-related human activity that affects succession and diversity. Off-road vehicles (ORVs), snowmobiles, and power boats also disturb natural ecosystems. Large areas of U.S. deserts, coastal dunes, and barrier islands have been dissected and rutted by ORVs, which destroy plant communities that may take centuries to recover.[70] ORVs are a major threat to endangered cacti,[71] reptiles, and ground nesting birds. Indeed, some ORV enthusiasts have opposed steps to save the endangered plants and animals in the remainder of California's Antioch Dunes. Snowmobiles damage vegetation less, but their noise may disturb animals that are energy limited (on the verge of starvation) in winter and can ill afford to be kept on the retreat. Many endangered Florida manatees (*Trichechus manatus*) bear unmistakable wounds and scars from boat propellers; boat and barge collisions are a major source of death among the remaining 750–850.[72]

But the adverse effects of transporting energy, materials, and people on ecological diversity can be diminished. Roads, pipelines, and canals need not always cross undisturbed natural habitats. Careful, farsighted weighing of the ecological, social, and economic benefits and costs of individual projects should be undertaken. In the planning of pipeline routes, existing pipeline, road, or rail rights-of-way should be used wherever possible. Pipeline sections can be buried or raised so that animals can move over or under them, just as the Trans-Alaska Pipeline was raised to provide underpasses for migrating caribou. Sometimes pipelines or railroads can replace canals at lower economic and environmental costs, or barriers to the movement of species can be emplaced to prevent unnatural biotic exchange. Recreational ORVs, snowmobiles, and power boats which jeopardize other, at least equally legitimate, values can be confined to selected places.

Crop Production

Paradoxically, modern agriculture is both a major beneficiary of and threat to biological diversity.

Each natural ecosystem has a characteristic trophic structure or hierarchy of feeding relationships. By trapping the sun's light to obtain energy, green plants such as oaks (*Quercus* spp.) and seagrasses (e.g., turtlegrass, *Thalassia testudinum*) function at the primary producer level. The grey squirrels (*Sciurus carolinensis*) and green sea turtles (*Chelonia mydas*) that feed on them are the first consumer level, the herbivores. The goshawks (*Accipiter gentilis*) and tiger sharks (*Galeocerdo cuvier*) that feed on these herbivores are carnivores, the next trophic level. A natural ecosystem usually has several or many species at most levels. Nutrients and energy are divided among more or less specialized feeders at each level,

so that most resources are efficiently used and regenerated, and few are lost to the system before they are repeatedly used at several levels.[73]

But natural ecosystems cannot usually support dense human populations because people consider most species inedible. For this reason, modern agroecosystems are managed to maximize productivity of harvestable species.[74] In crop production, both other primary producers (weeds) and herbivores (pests) are actively discouraged by plowing, weeding, or applying chemical pesticides. For range-fed livestock, desirable grasses are encouraged and plants with less nutritive value, other herbivores, and predators and parasites are discouraged. Thus intensive agriculture deliberately diminishes ecological diversity. Wild species are tolerated only when they do not threaten output (e.g., when geese glean cornfields in winter). With major fractions of the land devoted to agriculture (97 percent in Iowa), its effects on populations of wild species are substantial. Virtually all of some ecosystems, such as tallgrass prairie, have disappeared under the plow.

Because farming prevents ecological succession from progressing beyond early stages,[75] ecological diversity returns in varying degrees when crop and pasture lands are abandoned. Much of the Northeast was once farmland, although today's second growth forests harbor fewer native species than did primeval forests. Yet some agricultural practices deplete the soil and alter local hydrology, so that the land cannot readily return to an equally ecologically diverse condition.

Modern agriculture in effect reduces ecological diversity; it also discourages genetic diversity in crops, a phenomenon which has generated deep scientific concern. Indeed, population ecologist Paul Ehrlich and coauthors have stated: "[a]side from nuclear war, there is probably no more serious environmental threat than the continued decay of the genetic variability of crops." [76] How has this decay developed?

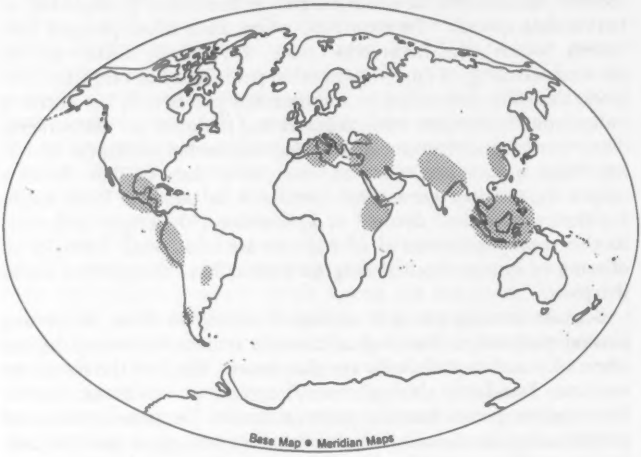
Of the approximately 300,000 higher plant species, only a few dozen crops are now major components of human diets.[77] A few plant families, including the grasses (wheat, corn, barley, rice), nightshades (potatoes, tomatoes, peppers), and legumes (peas, beans, peanuts) supply most human plant foods.

Most modern food crops were first planted by neolithic people. Primitive agriculture depended on a broad genetic base. In some "evolutionary cradles" of today's crop plants, the results of cultivating genetically diverse food crops are still apparent (see Figure 2–4). For example, in the Lake Titicaca Basin of South America, many potato species and hybrids grow side by side, allowing substantial genetic exchange. Farmers harvest potatoes of many sizes, shapes, skin colors, textures, flavors, and cooking properties.[78]

In primitive agroecosystems with genetically diverse crop plants, some genotypes inevitably produce better than others in any given year. Under the different weather and pest conditions of another

Figure 2-4

Geographical Areas of Exceptional Genetic Diversity for Crop Plants (Vavilov Centres)



Source: United Nations, Food and Agriculture Organization, filmstrip.

year, other genotypes bear more heavily. By modern standards, yields are not spectacular, but they are dependable, permitting humans to adopt an equilibrial strategy of existence.

As agriculture became more technology dependent, only strains that gave the highest yields under optimal conditions were used. Other kinds of plants, including relatives capable of interbreeding with these crop strains, were actively discouraged. Primitive agriculture gave way to industrialized agriculture using monocultures of genetically uniform, high-yield crop plants that depend on fertilizers and pest controls. There are substantial benefits from this strategy. It produces carefully tailored, uniform crops. Because maturation is nearly synchronous, large harvesting machines can replace hand labor. Selection can develop crops that do not bruise in mechanical harvest and that travel and store well and ripen on cue. But the costs and risks of modern agricultural practices are numerous and very serious, especially when methods developed for rich temperate countries are tried in poor tropical or subtropical ones. One of the risks is vulnerability to insects and diseases because the crops lack the mosaic pattern of species and genotypes that bars the spread of pests and pathogens in natural communities.

Monocultures are very unstable in the absence of weed and pest controls, and despite such measures agricultural production systems sometimes go awry. In 1970, an unexpected epidemic of southern corn leaf blight struck the U.S. corn crop. The fungus *Helminthosporium maydis* had never been a serious corn pathogen, but a virulent new mutant affected hybrid corn varieties having "T-cytoplasm," which was 70 percent of the crop. Under warm, damp conditions, the blight spread from the Great Lakes to the Gulf of Mexico. About 15 percent of the nation's corn crop, perhaps worth $2 billion, was destroyed; some states lost more than one-half their crop. A major setback for producers who lost entire crops, it increased livestock production costs nationwide. In countries such as Guatemala and Kenya, where one-half the diet is corn, a similar situation would have been a national disaster.[79] By the next year, the seed industry had produced impressive amounts of seed of nonsusceptible varieties, and the weather was less favorable to the fungus. Had the agricultural infrastructure been smaller or less developed, the epidemic may have been much more serious.

Ireland experienced such a disaster as a result of complete reliance on a genetically uniform strain of potato in 1845. Massive crop failures caused by the late blight fungus brought death, suffering, and emigration of millions.

Industrialized agriculture using genetically uniform varieties produces high yields in good years, but it may produce poor or no yields at all when unanticipated weather, crop epidemics, or fertilizer shortages occur.[80] Thus by relying on food resources that can fluctuate significantly, humankind has adopted an opportunistic strategy of existence which is not in keeping with its nature as an equilibrial species. Unless the risks of this strategy are fully recognized and allowances are made, the result could be episodic widespread hunger, boom-bust cycles in the global economy, and geopolitical destabilization. Nations can lower these risks by storing enough food to survive the worst possible crop failure or by depending on harvests of other nations. Food storage as a hedge against famine has a long tradition (e.g., Genesis, chapters 41–43). However, it is costly to build and maintain storage structures and difficult to control pests in stored food products. Dependence on other nations presupposes that they will have surpluses and will be willing to part with them. In the past, food from the United States has helped other nations, but the United States is not immune to crop failure, a point driven home by the southern corn leaf blight.

It is thus essential to be able to draw on genetic reservoirs to respond to fluctuating weather and rapidly evolving crop pathogens. Yet modern agriculture tends to kill the goose that lays the golden eggs. For example, an early success of the Green Revolution was the rice strain IR–8, which was widely used in the Philippines. Because is was susceptible to fungal diseases, growers switched to IR–20, which in turn was vulnerable to grassy stunt virus and brown

hopper insects. Its replacement, IR–26, appeared to be disease and pest resistant, but it could not withstand strong winds. An attempt to introduce genes for wind resistance using an older strain from Taiwan was hampered because almost all the original Taiwanese rice strains had been replaced by IR–8.[81]

To prevent similar occurrences, the world needs to maintain crop diversity for crossbreeding. Two basic approaches are available. Seeds can be stored at low temperatures, warmed, and planted at intervals to ensure viability, as the Department of Agriculture does in a number of gene banks. A disadvantage of this approach is that accidents (e.g., power failures) could destroy irrecoverable genetic resources. Alternatively, geographical areas of exceptional genetic diversity for crops and their ancestral species (see Figure 2–4) might in effect be "frozen" by setting them aside as preserves, within which Green Revolution varieties would be prohibited. Although indigenous peoples would thereby be denied some benefits of modern agriculture, farmers using traditional varieties could be subsidized.[82] A balanced mix of approaches would ensure continuation of the genetic base so that it will be available as needed.

Forestry

Forests are sources of building materials, fuel, paper, and chemicals. Forests are the habitat of more species than any other class of ecosystem. Not surprisingly, these two values often conflict and then biological diversity suffers. Many of the extinctions in historical times were of forest-dwelling species. In the next 20–60 years, world forests may well be threatened with extinctions at rates unprecedented since the end of the Cretaceous period, when dinosaurs and many other species died off.

Forests are diverse for many reasons. Climates are more constant within forests than outside—temperatures vary less, and rainfall and humidity are higher. Trees, vines, epiphytes, understory shrubs, and ground cover create structurally complex habitats, increasing feeding and hiding opportunities for animals. Wood can be excavated, allowing species to live or nest in tree trunks. Fallen logs are habitats for decomposers and their predators. As in most ecosystems, species richness increases sharply toward the tropics.

Opinions differ on whether harvesting trees is good for wildlife. In fact, the effects vary with the locality, management practices, and kinds of wildlife.

Unbroken mature northern coniferous forest (taiga) usually has few tree species and supports correspondingly few animal, decomposer, and small plant species. After taiga is cut, the early successional communities of herbs, shrubs, birch, and aspen support species such as moose (*Alces alces*) that mature taiga cannot. Thus local cutting can raise regional ecological diversity, but it decreases populations of caribou (*Rangifer tarandus*), which need shrubs and lichens of mature taiga in winter.[83] Many forest species, inextricably

tied to particular successional stages, prosper or disappear along with their habitats. Logging probably caused the extinction of the ivory-billed woodpecker (*Campephilus principalis*), whose only habitat was extensive mature southern deciduous forests with many standing dead trees. The precipitous worldwide decline of mature forest has undoubtedly eliminated many less conspicuous species as well.

The ecological consequences of forest management practices vary. The least disruptive timbering practice is selective felling of species (leaving some of each species standing to reseed the area) followed by careful removal. Leaving the branches, foliage, and stumps allows decomposers to return nutrients to the soil. Examples include ebony (*Diospyros ebenum*) harvest and removal by elephants in southern Asia and hickory (*Carya* spp.) harvest and horse-drawn removal in the eastern United States. Aside from temporarily opening small patches of forest canopy and floor and removing the nutrients in the logs, selective felling disturbs the forest relatively little.

Deviations from this method increase the changes in forest ecosystems and species. A common method of commercial forestry is to clearcut large areas and remove logs with heavy equipment on specially built roads. The land is then abandoned, or, in the most intensively managed forests (e.g., some Douglas fir (*Pseudotsuga menziesii*)-dominated forests in the Pacific Northwest), selectively bred seed or seedlings of a single species are sown and fertilizer and herbicides applied. This method produces even-age tree monocultures with few herbs or shrubs, minimal structural complexity, and no snags (dead standing trees) or fallen logs. Trees are not permitted to reach maturity because growth slows with age. Years after clearcutting large areas, runoff and soil erosion are much higher than normal, and streams warm in the sunlight and choke with sediment. Not surprisingly, all these changes decrease ecological diversity, and the new forest monoculture of genetically similar trees offers no barrier to the dispersal of diseases and pests. Typically, then, pesticides are applied. The forest effectively becomes a long-lived corn field.

Modern intensive management of forests aims to maximize yield. But enlightened forest managers can minimize the loss of biological diversity. They can retain the trees along streams to slow sedimentation and warming, and they can leave corridors of trees through which wildlife can move. They can clearcut in small patches so that forests of differing ages are available; they can leave snags and fallen logs, vary the species in the patches, allow some patches to reach maturity, stop herbicide applications after seedlings are established, seed the understory with herbaceous and bushy plants to minimize erosion and provide cover and food for wildlife, and use integrated pest management techniques rather than routinely spraying pesticides. These measures may decrease short-term profits but lessen damage to forest inhabitants and provide for sustainable

productivity, hence longer-term economic gains.

The threats to temperate forests are significant but manageable. However, the world's tropical forests are in much greater jeopardy, and fewer resources are available to save them.

Tropical moist (and wet) forests appear to be the world's most diverse ecosystems. A single hectare (2.47 acres) of Brazilian Amazonia has been found to contain 235 tree species; the same area of temperate forest has about 10. A square mile of Costa Rican forest has been found to contain 269 bird species, more than wildlife-rich Alaska, an area 500,000 times larger.[84] Of the world's estimated 5–10 million species, 2–5 million probably occur in tropical moist forests, which comprise only 6 percent of the earth's land surface. As the National Academy of Sciences reported, "no more than 15 percent—and possibly much less—have even been given a Latin name, and most are totally unknown." [85]

Vast numbers of beetles, the most diverse group of tropical insects, remain undiscovered (Elliott A. Norse).

Tropical moist forest species also have exceptional economic potential. Many species are almost untapped sources of food, a major consideration for tropical LDCs, which have the world's highest human population growth rates. Tropical forest organisms have evolved finely tuned adaptations to other species,[86] including biochemicals that discourage predators or parasites and that are sources of drugs and pesticides.

Adaptations to deter other species are of little use, however, when human activity disrupts the physical environment. For example, seeds in a family of Asian trees, the dipterocarps, germinate only between 23°–26° C (74°–79° F). In logged areas, soil can heat to over 40° C (104° F), killing the seedlings.[87]

Trees are also vulnerable to indirect effects of human activities. Tropical moist forest trees have evolved staggered fruiting times, so that fruit is always available to frugivorous birds and mammals.[88] Loss of a single tree species may cause fruit-eaters to starve, which can then lead to loss of the other trees that depend on frugivores to disperse their seeds.

The threats to tropical moist forest species are especially complex and difficult to resolve. Many LDCs cannot afford to deny industries permission to exploit forests for lumber or paper pulp or to prohibit landless, jobless peasants' hacking ever-expanding clearings in the forest to grow crops—even in sloping watersheds or other land unsuitable for sustainable agriculture. Indeed, the above two causes of forest loss are interrelated, because logging roads allow peasants to penetrate heretofore remote forest. A further threat is from another group, traditional slash-and-burn agriculturists, whose rapidly growing population is about 140 million.[89] They move from place to place, burning small patches of trees to free minerals in the tree biomass, which fertilizes the soil.[90] Often an area can be cropped for only a few years before nutrients are depleted or weeds take over. The farmers then move on. But logging operations, plantations, and cattle ranches have decreased the amount of land for slash-and-burn agriculture; hence pressures on the remaining areas are rising. As each area is burned more frequently, climax tree species fail to reach reproductive age, and the community changes to ecologically less diverse secondary forest. As with logging, excessive pressures from forest agriculturists can turn lush forests into barren wastelands.

In addition, a large, increasing fraction of the population in the LDCs depends upon wood and charcoal for cooking and warmth. Some estimates indicate that most tropical trees are cut for fuel.[91]

Other uses can cause irreparable loss, including inundation from hydroelectric and irrigation projects and clearing for mining, cattle ranching, plantations, human settlements, and industrialization. Loss of tropical forests could have consequences far beyond the borders of tropical nations, ranging from loss of songbirds (e.g., many warblers) that breed in temperate regions but winter in tropical forests to changes in global weather patterns.

There is considerable debate about the magnitude of the yearly loss or conversion of tropical moist forest; estimates range up to 245,000 square kilometers (95,000 square miles),[92] an area the size of New York and Pennsylvania combined. Two points are certain—tropical moist forests are biologically and economically very important, and, if present trends continue, they will disappear unless nations work together to learn about and manage them.

CHEMICAL POLLUTION

The number and amounts of environmentally damaging chemicals entering the biosphere have increased steadily since the beginning of the Industrial Revolution. At first, the effects went unnoticed or were of little concern. But with the publication of Rachel Carson's *Silent Spring*[93] in 1962, people and governments became aware of the risks of chemical pollution to the health of human beings and ecosystems.

Although U.S. laws have slowed the rate of increase in chemical pollution, thousands of toxic chemicals are still being emitted into the air, dumped into lakes, rivers, and oceans, and buried in or heaped upon the land. The pollutants are widely dispersed and concentrated by winds, currents, and the organisms that carry them in their bodies. Indeed, the discovery of DDT in Antarctic penguins far from possible sources and the DDT-caused decline of brown pelican (*Pelecanus occidentalis*) and peregrine falcon (*Falco peregrinus*) populations increased awareness of the intricacy of the relationship of all living things on this planet.

Chemical pollutants vary from the short-lived to the permanent and from the locally to the globally distributed. Their threat to biological diversity is generally in proportion to their persistence and ubiquitousness. Some pollutants are chemical elements (e.g., cadmium, barium, lead) that do not break down. Others (e.g., halogenated hydrocarbons such as lindane and polychlorinated biphenyls —PCBs) resist degradation for years or decades.

Although progress has been made in agriculture, the area affected by chemical pollutants from energy production, transportation, and utilization is increasing. The rapid worldwide increase of offshore oil and gas operations significantly increases the discharge of drill cuttings, drill fluids, completion fluids, and produced oily brines into marine ecosystems. Their physical and toxic effects[94] on marine species and communities merit close attention. Oil pollution from tankering can have serious effects on some species; the South African jackass or blackfooted penguin (*Spheniscus demersus*)[95] is particularly vulnerable. Increased burning of fossil fuels, particularly coal, leads to increased acidity of rain in Europe and North America.[96] The Canadian aurora trout (*Salvelinus fontinalis timagamiensis*) now appears to be extinct as a result of a process begun by increased acidification of fresh water ecosystems throughout its range.[97]

Species vary in susceptibility to chemical pollution. Some are far less sensitive than others, and even within species, vulnerability of life stages can vary considerably. For example, a study of two coral reefs in the Red Sea, one free of chemical pollution, the other subject to chronic oil pollution, initially showed a similar species composition. After a natural catastrophe, coral larvae recolonized the unpolluted reef 23 times faster than the reef polluted by oil.[98]

Chemical pollution is a threat to species and communities for another reason—the extent of their distributions varies greatly. Serpentine rock outcroppings, sphagnum bogs, or hot springs [99] may be only one-millionth the size of adjacent ecosystems. Often species from these island-like habitats and from islands occur nowhere else or are isolated from others of the same species. If chemical pollution destroys a local population, no recolonization can occur. Examples are *Vema hyalina,* an extraordinary tiny, limpet-like "dawn mollusc" which is known from a single submerged island, the Santa Rosa Ridge, off California [100] and the unique reefal ecosystems of the Flower Garden Banks in the Gulf of Mexico. Both could be threatened by chemical pollution from oil and gas operations slated for the area.

There are many ways to minimize the loss of biological diversity from pollution. Nonchemical pest controls can be employed (e.g., growing early maturing cotton varieties to lessen the need for pesticide spraying, thus diminishing harm to wildlife in adjacent areas), or, failing that, less persistent, more specific pesticides can be used. The area of pollution can be limited (e.g., by planting strips of "trap crops" to attract pests away from cash crops, thus reducing the need for spraying). In areas with unique species or communities, polluting activities can be changed or stopped altogether.

DESTRUCTIVE HARVEST AND CONTROL OF WILD SPECIES

Although physical and chemical habitat modification is now the most profound threat to ecological diversity, human predation and trade jeopardize many species throughout the world. Humans use wild animals and plants for food, medicine, fuel, clothing, shelter, tools, and ornaments and kill organisms regarded as competitors, predators, and parasites. A few wild species have kept pace with advances in harvesting technology, but many others have declined or disappeared, at least partly because of subsistence, sport, commercial, and pest-control hunting, trapping and fishing, and collecting by hobbyists.

Subsistence harvest, the predominant occupation of early humans, remains so for some societies. Yet it is an increasingly significant risk to ecological diversity, particularly for local endemics and species that have been reduced for other reasons. Subsistence harvest is a cause of concern for the survival of the bowhead whale and many plant species.[101] Indeed, the importance of subsistence foraging may increase as the exploding population forces landless, jobless, hungry people to eat whatever they can find.

The days when men shot bison from trains are long gone, but the legacy of similar practices remains, as shown in Table 2–1. U.S. sport hunters and fishermen have actively supported government wildlife conservation programs and opposed chemical pollution and unwise land use practices. The record of commercial hunters is not

so good. In the last century, commercial hunters used cannon loaded with scrap metal to kill wagonloads of passenger pigeons; along with habitat destruction, the practice caused the bird's extinction. More recently, egg robbers reduced Kemp's Ridley sea turtle from 40,000 to several hundred breeding females. Species valued for folk medicines, such as rhinoceroses and peyote cactus, have not fared much better.

Among the species most difficult to save are those valued by hobbyists, for their worth increases as they become rarer. The Aztec cactus (*Aztekium ritteri*), a unique cliff-dweller from a single locality in northern Mexico, is dislodged by collectors using long-handled rakes. Many do not withstand harvest and subsequent desiccation before being potted, and few survive and reproduce under artificial conditions. Unless rigorously protected, it will probably share the fate of some Florida tree snail races whose island-like hammock habitats were deliberately burned by shell collectors to corner the market.

Hunting and gathering threaten two other groups of species. Some species, such as the Carolina parakeet, gray wolf (*Canus lupus*), and *Bowenia serrulata*, a toxic Australian cycad, have been persecuted because they were viewed as crop or livestock pests. Other species are killed unintentionally. Decline of the endangered black-footed ferret (*Mustela nigripes*) has been accelerated by their eating

Rare and endangered black-footed ferrets on a South Dakota prairie. Efforts to control its prey have virtually ensured extinction of this weasel (Luther Goldman, U.S. Fish and Wildlife Service).

Table 2–1

Selected Plants and Animals Extirpated or Greatly Reduced by Excessive Harvest or Pest Control Activities

Species	Original range	Status	Use	Reasons for decline
Plants				
Dracaena ombet (Nubian dragon tree)	Djibouti, Ethiopia, Sudan	Vulnerable, possibly endangered [a]	Fuel and fiber for weaving	Subsistence harvest, habitat modification
Ariocarpus agavoides (Living rock cactus)	Northern Mexico	Vulnerable, possibly endangered [a]	Horticultural specimens	Commercial harvest
Animals				
Fishes				
Cynoscion macdonaldi (Totoaba)	Northern Gulf of California, Mexico	Endangered [b]	Food	Commercial fishing, incidental catch in shrimp trawls, habitat modification
Reptiles				
Lepidochelys kempi (Atlantic Ridley sea turtle)	Caribbean and adjacent western Pacific	Endangered [c]	Food (meat and eggs)	Private and commercial harvest, incidental catch in shrimp trawls, habitat modification
Birds				
Conurupsis carolinensis (Carolina parakeet)	Southern United States	Extinct circa 1914 [d]	None	Exterminated as a crop pest
Ectopistes migratorius (Passenger pigeon)	Central United States	Extinct 1914[d]	Food for humans and pigs	Private and commercial harvest, habitat modification
Numenius borealis (Eskimo curlew)	Hudson Bay shores	Endangered [d]	Food	Private and commercial harvest

Table 2–1 (continued)

Selected Plants and Animals Extirpated or Greatly Reduced by Excessive Harvest or Pest Control Activities

Species	Original range	Status	Use	Reasons for decline
Mammals				
Cervus canadensis canadensis (Eastern elk)	Eastern North America	Extinct early 1880s [a]	Food, hides	Private and commercial harvest
Bison bison (American bison)	North America, east of Rocky Mountains	Depleted [a]	Food, hides, and trophies	Private and commercial harvest, habitat modification
Monachus tropicalis (West Indian monk seal)	Caribbean	Extinct circa 1962 [a]	Food, hides, and oil	Commercial harvest
Balaenoptera musculus (Blue whale)	Panoceanic, especially Antarctic Ocean	Endangered [f]	Food, oil	Commercial harvest

[a] G. Lucas and H. Synge, *The IUCN Plant Red Data Book* (Morges, Switz.: International Union for the Conservation of Nature and Natural Resources, 1978), pp. 51–52, 305–306.

[b] 44 Fed. Reg. 29566–77 (1979).

[c] 35 Fed. Reg. 8491–98 (1970).

[d] James C. Greenway, *Extinct and Vanishing Birds of the World*, Special Publication No. 13 (New York: Committee for International Wildlife Protection, 1958), pp. 35–38.

[e] George A. Petrides, "The Management of Wild Hoofed Animals in the United States in Relation to Land Use," in F. Bourliere, ed., *Ecology and Management of Wild Grazing Animals in Temperate Zones* (Morges, Switz.: International Union for the Conservation of Nature and Natural Resources, 1960), pp. 181–201.

[f] 35 Fed. Reg. 18319–22 (1970).

prairie dogs (*Cynomys* spp.) poisoned by pest controllers. Similarly, shrimp trawls have drowned some of the remaining Kemp's Ridleys. Incidental destruction of wildlife can often be prevented; e.g., the National Marine Fisheries Service has worked with the shrimping industry to develop trawls that catch the shrimp but not sea turtles.

BIOLOGICAL POLLUTION (EXOTIC SPECIES)

Many government agencies and public interest groups work to counteract habitat modification, chemical pollution, and excessive harvest. A fourth major threat, the introduction of organisms into habitats where they do not normally occur, has received much less attention.[102]

Exotic (nonnative) species are introduced for food, furs, drugs, raw materials, recreation, aesthetics, and pest control. Accidental introductions occur when species accompany products (e.g., transplanted commercial oyster clumps) or vehicles in transit, when barriers to their dispersal are removed, or when they escape from captivity. In addition, unwanted pets are often released into new habitats.

Introduced organisms often fail to survive or reproduce and therefore have little effect on indigenous communities. (Some, including many traditional agricultural species, have lost their ability to survive without human assistance.) But when exotic species do become established, they may overwhelm the communities that they invade. Exotic species can diminish ecological diversity or agricultural productivity by acting as predators, parasites, or competitors.

In natural ecosystems, predators and prey coevolve form, physiology, behavior, or life history,[103] because predators that are more successful in acquiring prey—and prey that are more successful in thwarting predators—tend to be the progenitors of following generations. Island species and those from isolated island-like ecosystems are especially vulnerable to exotic predators because they evolved in relatively predator-free environments. Exotic carnivores can devastate fearless, flightless, or otherwise defenseless prey; exotic herbivores can have the same effect on plants lacking physical or chemical defenses.

Two Old World species, the black rat, *Rattus rattus,* and the Norway rat, *R. norvegicus,* were introduced accidentally to many islands by sailing ships. Unchecked by predators, they became major pests. The small Indian mongoose (*Herpestes auropunctatus*) was introduced to Hawaiian and Caribbean islands to control the rats, but it proved much better at controlling native lizards and ground-dwelling birds. It eliminated the dark-rumped petrel (*Pterodroma phaeopygia*) and Newell's shearwater (*Puffinus newelli*) from Molokai.[104] Similarly, introduced fishes can devastate native species and radically alter community structure and dynamics.[105]

Exotic herbivores also have exterminated island species. Goats killed off a number of plants endemic to California's Channel Islands, and introduced rabbits denuded Laysan Island in the Hawaiian chain, eliminating several endemic plant and bird species.[106]

Exotic herbivores can be major crop pests as well. The Codling moth (*Laspeyresia pomonella*), cabbage butterfly (*Pieris rapae*), and Mediterranean fruit fly (*Ceratitus capitata*) cost the United States many millions of dollars annually, and the pesticides used to control them harm native species.

Some of the most harmful exotic species are parasites. Because the parasite's survival depends on the host's, many naturally occurring host-parasite systems have coevolved in ways that minimize harm to the host. But when parasites or pathogens (a common term for parasitic fungi, protozoans, bacteria, and viruses) are introduced and the potential hosts have not evolved defenses, serious ecological effects are common.

New diseases introduced by Westerners decimated both the native Hawaiian people and birds. The introduced mosquito, *Culex pipiens*, spread diseases such as bird malaria. Within 30 years, many endemic Hawaiian birds were extinct.[107]

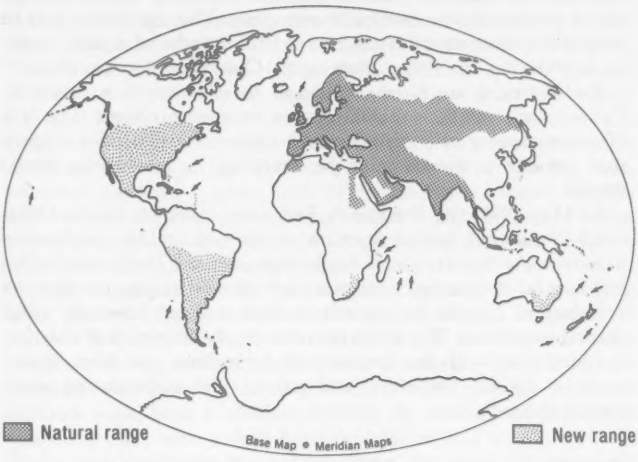
The American chestnut, *Castanea dentata*, was one of the most abundant and valuable trees of the Eastern deciduous forests. About 1900, the chestnut blight fungus, *Endothia parasitica* was introduced on Chinese chestnut trees (*C. mollissima*). Although it scarcely damaged its original hosts, it ravaged the American chestnuts,[108] and within 20 years, virtually all of them were dead. Shoots still sprout from old stumps, reach 15–25 feet, and die back as the blight takes effect. Only a few trees survive, apparently missed by the blight. In effect, the American chestnut and, to varying degrees, the species that depended on it are gone, although there is hope that researchers can fight the fungus with a virus.[109]

Exotic species also eliminate native species through their superior competitive abilities. The house sparrow (*Passer domesticus*), introduced to the Americas by homesick immigrants (Figure 2–5), displaced bluebirds, wrens, swallows, and other native birds by usurping nesting holes and food sources.[110] House sparrows and exotic starlings and pigeons (*Columba livia*) are especially abundant in cities and disturbed areas.

Many familiar weeds are exotics, including crabgrass (*Digitaria ischaemum*), dandelion, and Russian thistle or tumbleweed (*Salsola kali*). Exotic kudzu and water hyacinth crowd and shade out native terrestrial and aquatic plants throughout much of the Southeast. In the Antioch Dunes in California, competition from exotic weeds threatens unique endemic plants and animals. An exotic green alga, *Codium fragile*, is detrimental to New England shellfish and the shellfishing industry. It attaches to hard objects, including scallops, oysters, and other clams. When storms sweep the "oyster thief" and

Figure 2-5

World Distribution of the House Sparrow



Source: J.D. Summers-Smith, *The House Sparrow* (London: Willmer Brothers and Haram, Ltd., 1963), p. 245 (copyright © by Collins Publishers).

attached bivalves away from their subtidal communities, the exposed shellfish die on beaches.[111]

Established exotic species are often ineradicable because most are opportunists that reproduce and disperse rapidly and adapt to new environmental challenges easily. Partial control, often the best that can be hoped for, ends when efforts are relaxed. Preventing introduction is clearly preferable to combatting established exotics.

Few countries, if any, have adequate programs to control trade, maintenance, and disposal of exotics, and the public often pressures government agencies thoughtlessly. The Department of Agriculture is often criticized for destroying illegally imported exotic birds to control Newcastle disease. Similarly, the Departments of the Interior and the Navy have been opposed for their efforts to eradicate feral goats and burros on federal lands despite the harmful effects of these animals on native organisms.

There is room for improvement at the government level as well. Too often government agencies deliberately introduce exotic species with insufficient attention to the consequences. To control the exotic puncture-vine (*Tribulus terrestris*) in the early 1960s, California and Arizona officials introduced two weevil species that feed on it in its native India.[112] Although California experts warned that

the beetles might attack native wildflowers in the genus *Kallstroemia,* the introductions proceeded. Unfortunately, the long-term effects are unknown; no data on the impact of the experiments were kept and no followup studies made. But the weed thrives and the native plants are now assailed by new pests. This experience may be repeated by state agencies eager to control introduced aquatic weeds by introducing the Asian grass carp, *Ctenopharyngodon idella.*[113]

Exotic species are often introduced to solve complex problems. Yet simplistic solutions seldom resolve complex problems. The lack of understanding of population and community dynamics suggests that extreme prudence must be exercised in introducing exotic species.

In May 1977, the President's Executive order on Exotic Organisms [114] directed federal agencies to use their existing authorities to restrict the importation of exotic organisms and their introduction into natural ecosystems. Exceptions are allowed for species that the Secretary of Interior or Agriculture finds will not adversely affect natural ecosystems. The order provides for the Secretary of Interior, in consultation with the Secretary of Agriculture and other agency heads, to develop procedures and activities for implementing provisions of the order.

STRATEGIES FOR CONSERVING BIOLOGICAL DIVERSITY

Many routine activities of humankind—construction, food production, and mining—diminish biological diversity. Although adverse impacts can often be reduced through modification of these activities, demographic, economic, social, and political trends lead to the projection that the decline in genetic and ecological diversity will probably continue in the foreseeable future.[115] But in addition to mitigating the damage from development, we can also take positive steps to preserve our biological heritage. There are three main conservation strategies: the gene bank-zoo-botanical garden approach, the species approach, and the ecosystem approach.

THE GENE BANK-ZOO-BOTANICAL GARDEN APPROACH

The gene bank-zoo-botanical garden approach involves preserving threatened or vanishing organisms or samples of their genetic material (e.g., sperm, seeds, fertilized embryos, tissues) in facilities whose purpose is maintenance and propagation.

Agricultural crop gene banks, ranging from substantial seed storage facilities to kitchen-style freezers, exist throughout the world.[116] Although gene banks are clearly important, they have significant disadvantages.[117] Storage is not yet possible for many species. Errors, accidents, or vandalism can and do cause irrecoverable losses. In

addition, species in storage do not evolve, although their pathogens may continue to do so in the outside world.

Preservation of species that would otherwise become extinct is an increasingly important function of zoos, botanical gardens, and aquaria. Some species, such as Pere David's deer (*Elaphurus davidianus,* native to China), Wood's cycad (*Encephalartos woodii,* from South Africa), and Cookes kokio (*Kokia cookei,* a small Hawaiian tree), are already extinct in the wild and survive only in zoos and botanic gardens. Others gravely endangered in the wild (e.g., some lemurs and marmosets) may not long survive except in captivity. Indeed, as habitat destruction proceeds worldwide, zoos, botanical gardens, aquaria, and other managed habitats outside species' natural ranges may well become increasingly important in the preservation of biological diversity. Nevertheless, there are problems with these arks for vanishing species.[118]

Many organisms do not fare well in captivity. In the poorest zoos, jaguars (*Panthera onca*), which once ranged over tens of square miles, may be confined to tens of square feet. Instead of the countless visual, auditory, tactile, and chemical stimuli from encounters with other jaguars, prey, and other species, there are concrete walls, bars, a wooden platform for resting, and perhaps a scratching post, with a daily horsemeat ration at a scheduled hour. Under such conditions it is not surprising that many zoo organisms behave abnormally. Failure to mate or care for young is all too common. Better zoos provide a larger, more stimulating environment, but it is often impossible to meet minimum requirements for normal behavior and reproduction. For example, the cost of a cage that is large enough for the mating flights of large raptors, such as eagles, can be prohibitive.

A further problem of captive animal populations is loss of genetic variability.[119] Both random expression of deleterious traits and loss of valuable ones increase with decreasing population size. The results include lower reproductive rates and survival of young.[120] Few zoos can afford to keep sufficiently large populations to eliminate this problem, especially of the larger animals. One way to increase populations is for zoos to adopt special themes, emphasizing many fewer species with more members of each, rather than to have one of each, as many zoos do. Exchanges between zoos can also lessen the problem when there is sufficient genetic variability in the captive population as a whole.

When the loss of species and ecosystems is unavoidable, the gene bank-zoo-botanical garden approach is a lastditch strategy for conserving biological diversity. According to the National Academy of Sciences,

> [a]fter weighing all available measures for preserving endangered species under controlled conditions, we are repeatedly forced to the conclusion that the only reliable method is in the natural habitat. Knowledge required to preserve all of these organisms under artificial conditions is not available and, if it were, this approach would be prohibitively expensive.

Preservation in nature does not require that we understand it, only an awareness that it must not be destroyed. When preservation in nature is not possible, intelligent zoo or garden maintenance, with encouragement of breeding potentiality, offers a possible alternative.[121]

THE SPECIES APPROACH

The species approach identifies one or a group of closely associated species in need of special protection for their survival in their native settings. Species selected for conservation efforts are usually in one of two categories. The first includes wild plants and animals taken primarily for useful parts and products or for sport, such as wild rice (*Zizania aquatica*), longleaf pine (*Pinus palustris*), abalone (*Haliotis* spp.), largemouth bass (*Micropterus salmoides*), and white-tailed deer (*Odocoileus virginianus*). Many would not be able to provide their benefits without programs tailored to regulate harvest, supplement populations, or improve habitats. The second category includes species currently without major utility but which generate special concern and are widely recognized as worth saving from extinction. Examples are whooping cranes (*Grus americana*), California condors (*Gymnogyps californianus*), polar bears (*Thalarctos maritimus*), gray whales (*Eschrictius gibbosus*), cacti, ground-living orchids, and carnivorous plants.

The species approach has had conspicuous successes—bison (*Bison bison*) and sea otters (*Enhydra lutris*) are just two. But there have also been dismal failures. One reason is that an inseparable component of a species' ecological niche (its functional position in a community of organisms, essentially its "job") is its habitat. The population size and status of a species can be roughly estimated with knowledge of its habitat size. Florida's dusky seaside sparrow (*Ammospiza maritima nigrescens*), perhaps North America's rarest bird, is critically endangered by the loss of its coastal marsh habitat. Draining and burning the marshes for agriculture apparently caused the decline from about 900 in 1968 to perhaps a dozen today.[122] Similarly, the snail darter, a small fish, is critically endangered because nearly all the free-flowing riverine habitat that it requires was dammed. Habitat protection and improvement measures are used increasingly often in species-oriented conservation programs.

A further limitation of the species approach merits special discussion. Not all species needing protection are equally likely to receive it. As large warm-blooded terrestrial vertebrates, humans feel relationship with and concern for species sharing these attributes or for those, like carnivorous plants or corals, that are especially appealing for other reasons. In the United States, wolves are favored over ferrets, porpoises over sea turtles, butterflies over nudibranchs, swallows over dragonflies, and animals over plants; the point is demonstrated by the disproportionate allocation of conservation efforts to favored species. For example, almost 70 percent of the species that have been determined to be endangered or threatened are mammals

and birds. Efforts to protect endangered Furbish louseworts and snail darters have been derided by some people who would not question humpback whale (*Megaptera novaeangliae*) or peregrine falcon conservation. Although the nation's inshore coastal waters have been altered no less than the land and fresh waters, and the outer continental shelves may be comparably assaulted, no marine plant or invertebrate is on the Endangered Species List.

Part of the explanation is that more is known about mammals and birds than about other groups. Indeed, very few mammals or birds remain to be discovered, and at least something is known about the ranges, habitat requirements, life histories, and abundances of most of those found in the North Temperate Zone. In contrast, millions of species in groups few people would invite into their homes—fungi, marine worms, and insects, among others—have not been cataloged, let alone understood, by biologists. Many others are known only as preserved specimens in scientific collections. Some are probably abundant, others verging on extinction. In a nation firmly committed to saving blue whales (*Balaenoptera musculus*) and bald eagles (*Haliaeetus leucocephalus*), relatively few people are equally committed to less noble or appealing organisms. Yet saving a mold, sponge, or beetle may ultimately be of greater consequence for humankind.

Despite its shortcomings, the species approach can work quite well. If the species is conspicuous and easily recognized and its population dynamics well understood, measures such as posters warning hunters to avoid shooting whooping cranes, creel limits on steelhead trout (*Salmo gairdneri*), fences around sea turtle nests to exclude predators, and prohibitions on picking sea oats (*Uniola paniculata*) can help in their conservation.

THE ECOSYSTEM APPROACH

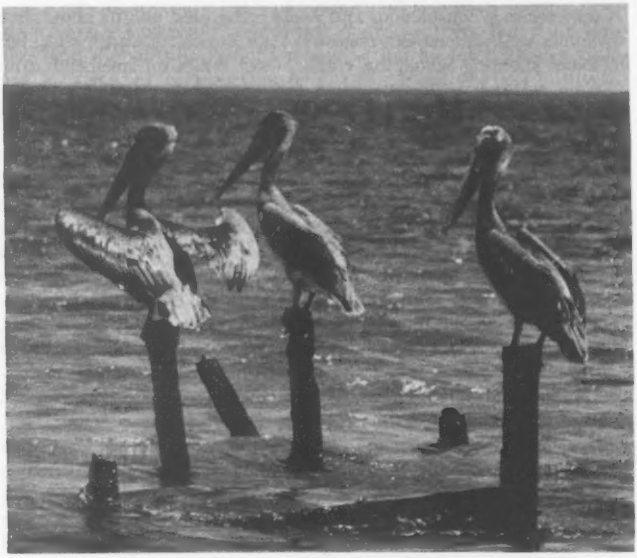
Managing for the enhancement of yields or survival of one species invariably affects others, benefiting some, harming some. In contrast, the ecosystem approach intentionally preserves diversity rather than doing so incidental to maximizing one or a few kinds of organisms. It attempts to define biologically meaningful, rather than political, boundaries for reserves so that they can continue as self-sustaining ecological units. The underlying idea is that an undisturbed ecosystem will permit a wide variety of organisms to exist in a quasinatural balance with minimal human subsidies.

The ecosystem approach is not without costs and problems. The risk of extinction from random environmental fluctuations—such as an unusually dry season or an epidemic—rises as population size decreases, in part because declining populations lose genetic variability and are therefore less able to respond to environmental change. For this reason, some species that have been reduced to low levels by human activities cannot recover without specially designed conservation measures.

Ecosystem preserves must be sufficiently large for species to survive in their natural settings; for some species, particularly large predators and scavengers (e.g., monkey-eating eagles, *Pithecophaga jefreyi;* tigers, *Panthera tigris*), very large areas are essential. Defining the amount of land, fresh water, or marine area needed to ensure self-sustaining ecosystem functioning is among the most crucial research challenges of the next decades.

For species that move between ecosystems, the migration route is only as safe as the most dangerous section. The critically endangered giant Siberian crane (*Grus leucogeranus*), for example, is protected in its summer range in the USSR and its winter range in India, but at points along its migration route, it is considered merely a large, tasty bird.[123] Because hunting and fishing can be important to local or national cultures, attempts to conserve species that cross political boundaries are vulnerable to charges of foreign imperialism, genocide, or cross-cultural insensitivity.

Ecosystems are also vulnerable to events beyond their boundaries and may fall victim to the effects of activities that decisionmakers did not (or chose not to) imagine. Many environmentally concerned people recognized that diverting the flow of water to Florida's Everglades and Big Cypress Swamp would seriously alter the unique character of these areas. But no one foresaw that the agricultural chemi-



Brown pelicans in the Florida Keys. The unforeseen effects of pesticides on the food chain nearly caused the extinction of this species on the west and Gulf coasts. (Elliott A. Norse)

cal DDT could adversely affect brown pelicans at sea or that emissions from smokestacks in Ohio could turn lakes in New York into acidic biological deserts.

Indeed, natural or anthropogenic climatic changes (e.g., possible global warming caused by CO_2 buildup) may be the most serious threat to biological diversity in ecosystem reserves. During major climatic changes, as have occurred repeatedly throughout the Quaternary era, many species have avoided extinction by colonizing adjacent, newly suitable areas while abandoning old ones. But the increasing fragmentation of ecosystems suggests that many species will have nowhere to go when the climate changes.

Nevertheless, the ecosystem approach has many substantial advantages. Because human ecological knowledge is incomplete, there is a great virtue in letting nature take its course rather than intervening—action which may be well-intended but is sometimes misguided or even heavy handed. Because natural selection favors the evolution of adaptations to handle the natural contingencies that organisms encounter, most species in well-designed ecological reserves will maintain abundance levels and escape extinction indefinitely without species-oriented help so long as they are not deprived of feeding, hiding, and breeding places and are not polluted, hunted, or harassed severely. Providing sufficient tracts of undisturbed land, fresh water, or sea obviates the need for heroic intervention to prevent extinction. A further advantage to the ecosystem approach is that once land is purchased (if purchase is necessary), administering ecological reserves is much less costly than managing species one by one.

U.S. POLICIES ON BIOLOGICAL DIVERSITY

A wide variety of federal activities affect biological diversity, including both species- and ecosystem-oriented programs.

THE ENDANGERED SPECIES ACT

The Endangered Species Act[124] is one of three federal laws passed specifically to conserve species in danger of extinction. It gives the Secretary of Commerce primary responsibility for the recovery of some marine species and the Secretary of Interior responsibility for all others. The Act authorizes the Secretaries to identify endangered or threatened species, designate habitats critical to their survival, establish and conduct programs for their recovery, and enter into agreements with states and assist other countries to conserve endangered and threatened species. The Secretaries of Commerce, Interior, and Agriculture are authorized to enforce prohibitions against or issue permits controlling the taking, harassing, and trading in endangered and threatened species. In addition, the Secretaries of Interior and Agriculture are authorized to license and monitor im-

porters and exporters of wild annimals and plants, to acquire lands to conserve animals and plants, and to implement the Convention of International Trade in Endangered Species of Wild Fauna and Flora and the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere. It also directs federal agencies not to carry out, fund, or authorize actions that may jeopardize the existence of or modify the habitats of endangered or threatened species.

Implementation has been controversial. Concern about delaying or stopping particular projects (construction of the Tellico Dam, for example) led to amendment of the Act in 1978.[125] The amendments complicated and lengthened procedures for designating species as endangered or threatened and generally weakened previous commitments to protect them and their habitats. Nevertheless, there has been substantial progress in identifying endangered and threatened species and in establishing programs for their conservation. Table 2–2 shows the number of U.S. and foreign species on the Endangered and Threatened Species Lists.

Table 2–2

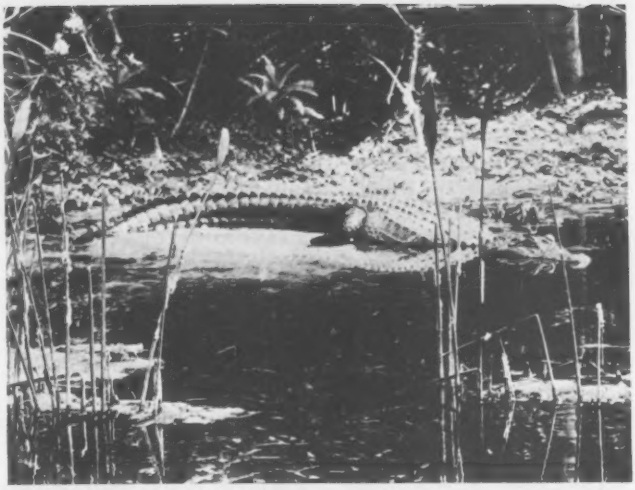
Number of Animals and Plants Designated or Proposed as Endangered or Threatened Species

	Endangered			Threatened		
Category	United States	Foreign	Total	United States	Foreign	Total
Mammals	32	242	274	3	20	23
Birds	66	158	224	3	0	3
Reptiles	13	61	74	10	4	14
Amphibians	5	8	13	3	0	3
Fishes	33	15	48	12	0	12
Snails	2	1	3	5	0	5
Clams	23	2	25	0	0	0
Crustaceans	1	0	1	0	0	0
Insects	7	0	7	4	1	5
Plants	49	2	51	7	3	10
Total	231	489	720	47	28	75

Number of critical habitats listed = 35.

Source: U.S. Fish and Wildlife Service, *Endangered Species Technical Bulletin* 5(8):16 (1980).

Although no animal or plant species has recovered sufficiently to be completely delisted, several species or populations have been upgraded from endangered to threatened. Perhaps the most notable success is the American alligator (*Alligator mississippiensis*). Once widely depleted by habitat modification and harvest, alligators are now sufficiently common in some places that controlled commercial harvest is permitted. Yet many species in jeopardy (perhaps as many



The American alligator in the Weekiwachi River, Florida. This species is a conservation success story—it was endangered and is now classified as threatened (Rex G. Schmidt, U.S. Bureau of Sport Fisheries and Wildlife).

as 2,500 plant species in the United States[126]) have yet to be designated endangered or threatened. Further, provisions for the recovery of listed species lag behind the listing itself. Less than 15 percent of the listed species have been assigned recovery plans or recovery teams. Although many listed species may be able to survive under the passive protection of the Act, others will require specific recovery efforts to avoid extinction.

Developing and implementing recovery programs for individual species are a time-consuming and costly method of conserving ecological diversity. Neither the United States nor other countries have the resources to develop individual conservation programs for every species that may be jeopardized. Although the Act is useful in preventing extinctions and facilitating recoveries, it should not be considered the primary means for conserving biological diversity.

THE CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FAUNA AND FLORA

In 1973, representatives of 80 countries concluded the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)[127] for the control of trade in species threatened by overharvest. In addition to the text for the treaty, the representatives also developed lists of protected wild animals and plants. Their work was the culmination of over 10 years' effort begun by the Interna-

tional Union for Conservation of Nature and Natural Resources. As of August 1980, 58 nations were party to the CITES.

The CITES directs nations to issue permits or certificates to accompany specimens of protected species in international trade, to establish management and scientific authorities to assess the impacts of the proposed trade and the well-being of specimens traded, and to implement and enforce the trade controls. Implementation and enforcement are not inexpensive, and the nations differ in their progress toward full compliance. Nevertheless, implementation appears to have contributed significantly to the conservation of a number of animals and plants and has reinforced national conservation programs. The usefulness of the CITES as a conservation tool may well improve as it is more fully implemented. Harvest of some sea turtles and crocodiles, for example, is reported to have declined as a result of CITES control.

THE CONVENTION ON NATURE PROTECTION AND WILDLIFE PRESERVATION IN THE WESTERN HEMISPHERE[128]

The United States is among 17 signatories to this treaty, ratified in 1941. Its purpose is to promote cooperation among the American republics to conserve species in their natural habitats. The Convention directs the party nations to establish reserves and to adopt laws to protect and conserve their wild fauna and flora.

Although the Convention has been the basis for conservation programs in several nations, its provisions have not generally been implemented. Representatives of the parties recently met on several occasions to explore ways to revitalize this Convention.

ADDITIONAL SPECIES-ORIENTED PROGRAMS

In addition to the initiatives discussed above, state and federal governments have promulgated many domestic statutes and have entered into other international agreements that promote conservation of ecological diversity. Among the federal efforts are the Marine Mammal Protection Act of 1972,[129] the Interim Convention for Conservation of North Pacific Fur Seals,[130] the Convention for the Preservation of Migratory Birds,[131] the Convention for the Protection of Migratory Birds and Game Mammals,[132] the Convention for the Protection of Migratory Birds and Birds in Danger of Extinction and Their Environment,[133] the International Convention for the Regulation of Whaling,[134] the Agreement on the Conservation of Polar Bears,[135] the Antarctic Treaty,[136] the Convention Concerning the Protection of the World Cultural and Natural Heritage,[137] and numerous bilateral and multilateral fisheries agreements.

International conservation agreements promote conservation of migratory species and wild animals and plants throughout the world.

Nevertheless, concern about the impact of international agreements on state conservation agency authority threatens to inhibit U.S. involvement in international conservation efforts. At the 45th North American Wildlife and Natural Resources Conference, a state official urged caution in entering agreements not directly benefiting the United States.[138] Much of the concern expressed by state conservation agencies stems from disagreement on listing standards for the CITES and on increased federal oversight of state programs that resulted from the inclusion of U.S. species in the treaty appendices. State officials argue that such international commitments cause them to spend financial resources in determining the status of species less deserving of attention than the species that they have identified. Present attitudes of the state agencies will surely delay U.S. ratification of the Migratory Species Treaty,[139] opened for ratification in 1979, and may well inhibit implementation of existing agreements.

ECOSYSTEM-ORIENTED PROGRAMS

Although species-oriented state, federal, and international efforts can slow or reverse the decline of many species, ecosystem-oriented efforts are necessary to prevent massive extinctions. Sometimes ecosystem protection is accomplished through other programs. Essentially intact ecosystems of many kinds occur on federal lands, including National Parks, Monuments, Seashores, Wilderness Areas, Marine and Estuarine Sanctuaries, Wild and Scenic Rivers, multiple use lands, and military reservations. Frequently the conservation of biological diversity is only one of several uses of these areas, and it may be subordinate or even incidental to the primary land use. Other uses may include mining, oil and gas production, forestry, grazing, commercial fishing, hunting, recreation, and military training. Sometimes the other uses are compatible with conserving biological diversity.

Nevertheless, the United States does not have a systematic program for conserving unique and representative ecosystems and their species. A number of federal agencies participate in Man and the Biosphere programs of the United Nations, including the Biosphere Reserve Program. The Federal Committee on Ecological Reserves, a group of scientists from federal agencies, has examined ecological research on federal lands for several years. A national effort to conserve unique and representative ecosystems would help minimize conflicts between development and conservation by ensuring the protection of intact, self-sustaining communities of diverse flora and fauna. Cost effectiveness would be a particular advantage of such an effort.

As the International Union for Conservation of Nature and Natural Resources stated in its *World Conservation Strategy,*

> The preservation of [biological] diversity is both a matter of insurance and investment—necessary to sustain and improve agricultural, forestry

and fisheries production, to keep open future options, as a buffer against harmful environmental change, and as the raw material for much scientific and industrial innovation—and a matter of moral principle.[140]

The earth's living resources are an incomparably rich national and global bank account. If they are managed properly, we can draw on the account in perpetuity, without depleting it. Conservation of biological diversity is the highest form of thrift.

REFERENCES

1. V.B. Scheffer, "The Last Days of the Sea Cow," *Smithsonian* 3 (10): 64–67 (1973); L. Stejneger, "How the Great Northern Sea Cow (*Rhytina*) Became Exterminated," *American Naturalist* 21:1047–54 (1887); L. Stejneger, *Georg Wilhelm Steller, The Pioneer of Alaskan Natural History* (Cambridge, Mass.: Harvard University Press, 1936), pp. 315, 318, 354–57.
2. James Fisher, Noel Simon, and Jack Vincent, *Wildlife in Danger* (New York: Viking Press, 1969), pp. 112–20; Norman Myers, *The Sinking Ark: A New Look at the Problem of Disappearing Species* (New York: Pergamon Press, 1979), p. 5.
3. Paul A. Opler, "The Parade of Passing Species: A Survey of Extinctions in the U.S.," *The Science Teacher* 43(9):30–34 (1976).
4. Norman Myers, *supra* note 2.
5. Luis W. Alvarez, Walter Alvarez, Frank Asaro, and Helen V. Michel, "Extraterrestrial Cause for the Cretaceous-Tertiary Extinction," *Science* 208:1095–1108 (1980); R. Ganapathy, "A Major Meteorite Impact on the Earth 65 Million Years Ago: Evidence from the Cretaceous-Tertiary Boundary Clay," *Science* 209:921–23 (1980); Kenneth H. Hsu, "Terrestrial Catastrophe Caused by Cometary Impact at the End of Cretaceous," *Nature* 285:201–203 (1980); J. Smit and J. Hertogen, "An Extraterrestrial Event at the Cretaceous-Tertiary Boundary," *Nature* 285:198–200 (1980).
6. Hugh H. Iltis, John F. Doebley, Rafael Guzman M., and Batia Pazy, "*Zea diploperennis* (Gramineae): A New Teosinte from Mexico," *Science* 203:186–88 (1979); Noel D. Vietmeyer, "A Wild Relative May Give Corn Perennial Genes," *Smithsonian* 10(9):68–76 (1979).
7. Janis Antonovics and A.D. Bradshaw, "Evolution in Closely Adjacent Plant Populations, VIII. Clinal Patterns at a Mine Boundary," *Heredity* 24:349–62 (1970); R.K. Selander and S.Y. Yang, "Biochemical Polymorphism in Feral House Mouse Populations," *Genetics* 60:224 (1968).
8. John D. Buffington, "Temperature Acclimation of Respiration in *Culex pipiens* and the Influence of Seasonal Selection," *Comparative Biochemistry and Physiology* 30:865–78 (1969).
9. Paul R. Ehrlich, Anne H. Ehrlich, and John P. Holdren, *Ecoscience: Population, Resources, Environment* (San Francisco: W.H. Freeman and Company, 1977), p. 124.
10. Michael L. Bonnell and Robert K. Selander, "Elephant Seals: Genetic Variation and Near Extinction," *Science* 184:908–909 (1974).
11. Charles W. Schaller, "Utilizing Genetic Diversity in the Improvement of Barley Cultivars," *California Agriculture* 31(9):18–19 (1977).
12. James A. Estes, Norman S. Smith, and John F. Palmisano, "Sea Otter Predation and Community Organization in the Western Aleutian Islands, Alaska," *Ecology* 59:822–33 (1978); David O. Duggins, "Kelp Beds and Sea Otters: An Experimental Appraisal," *Ecology* 61:447–53 (1980).

13. Frederick C. Pearson III and Marlys Weary, "The *Limulus* Amebocyte Lysate Test for Endotoxin," *Bioscience* 30:461–64 (1980); Peggy Thomson, "Value Is Extracted from a Nuisance," *Smithsonian* 6(1): 40–47 (1975).
14. Paul R. Erlich et al., *supra* note 9, at 959–66.
15. U.S. Bureau of the Census, *Current Population Reports: Illustrative Projections of World Populations to the 21st Century* (Washington, D.C.: U.S. Government Printing Office, 1979), p. 17.
16. Kenneth E.F. Watt, *Principles of Environmental Science* (New York: McGraw-Hill Book Company, 1973), p. 211.
17. Council on Environmental Quality and U.S. Department of State, *The Global 2000 Report to the President: Entering the Twenty-First Century*, Vol. Two, *The Technical Report* (Washington, D.C.: U.S. Government Printing Office, 1980), p. 97.
18. David B. Kelley, Jack D. Norlyn, and Emanuel Epstein, "Salt-Tolerant Crops and Saline Water: Resources for Arid Lands," in J.R. Goodin and David K. Northington, *Arid Land Plant Resources* (Texas: Texas Technical University, 1979), pp. 326–34.
19. National Academy of Sciences, *The Winged Bean—A High-Protein Crop for the Tropics* (Washington, D.C., 1975), pp. 1–2.
20. Richard Felger and Mary Beck Moser, "Eelgrass (*Zostera marina* L.) in the Gulf of California: Discovery of Its Nutritional Value by the Seri Indians," *Science* 181:355–56 (1973).
21. L.M. Talbot, "Comparison of the Efficiency of Wild Animals and Domestic Livestock in Utilization of East African Range Lands," in *Conservation of Nature and Natural Resources in Modern African States*, New Series 1 (Morges, Switz.: International Union for Conservation of Nature and Natural Resources, 1963), pp. 329–35.
22. Norman Myers, *supra* note 2, at 67.
23. L.M. Stevens, A.L. Steinhauer, and J.R. Coulson, "Suppression of the Mexican Bean Beetle on Soybeans with Annual Innoculative Releases of *Pediobius foveolatus*," *Environmental Entomology* 4:947–52 (1975).
24. Melvin Calvin, "Petroleum Plantations for Fuel and Materials," *BioScience* 29:533–38 (1979).
25. Karen A. Bjorndal, "Cellulose Digestion and Volatile Fatty Acid Production in the Green Turtle, *Chelonia mydas*," *Comparative Biochemistry and Physiology* 63A:127–33 (1979).
26. National Academy of Sciences, *Making Aquatic Weeds Useful—Some Perspectives for Developing Countries* (Washington, D.C., 1976), p. 144.
27. National Academy of Sciences, *Leucaena: Promising Forage and Tree Crop for the Tropics* (Washington, D.C., 1979), p. 49.
28. Vincent P. Gutschick, "Energy Farming," *BioScience* 30:221 (1980).
29. National Academy of Sciences, *Guayule: An Alternative Source of Natural Rubber* (Washington, D.C., 1977), pp. 1–10.
30. National Academy of Sciences, *Products from Jojoba: A Promising New Crop for Arid Lands* (Washington, D.C., 1975), p. 6.
31. Information supplied by T. Austin Campbell, U.S. Department of Agriculture.
32. *Ibid.*
33. Norman R. Farnsworth and Ralph W. Morris, "Higher Plants—The Sleeping Giant of Drug Development," *American Journal of Pharmacy* 148(2):46–52 (1976).
34. Elliott A. Norse, "Physicochemical and Biological Stressors as Distributional Determinants of Caribbean and Tropical Eastern Pacific Swimming Crabs," in James H. Thorp and J. Whitfield Gibbons, eds., *Energy and Environmental Stress in Aquatic Systems*, U.S. Department of Energy Symposium Series CONF–771114 (Springfield, Va.: National Technical Information Service, 1978), pp. 120–40; Lawrence

B. Slobodkin and Howard L. Sanders, "The Contribution of Environmental Predictability to Species Diversity," *Brookhaven Symposia in Biology*, Vol. 22, *Diversity and Stability in Ecological Systems*, pp. 82–85 (1969).

35. J.B.C. Jackson and Leo Buss, "Allelopathy and Spatial Competition among Coral Reef Invertebrates," *Proceedings of the National Academy of Sciences, USA* 72:5160–63 (1975); R.H. Whittaker and P.P. Feeny, "Allelochemics: Chemical Interactions between Species," *Science* 171:757–70 (1971).
36. Gerald J. Bakus and Gerardo Green, "Toxicity in Sponges and Holothurians," *Science* 185:951–53 (1974).
37. David Levin, "Alkaloid-Bearing Plants: An Ecogeographic Perspective," *American Naturalist* 110:261–84 (1976).
38. Jonathan L. Hartwell, "Types of Anticancer Agents Isolated From Plants," *Cancer Treatment Reports* 60:1031–68 (1976); Matthew Suffness and John Douros, "Drugs of Plant Origin," *Methods in Cancer Research* 16:73–126 (1979).
39. Aldo Leopold, "The Land Ethic," in *A Sand County Almanac, With Essays on Conservation from Round River* (New York: Oxford University Press, 1949), pp. 246–47.
40. David Ehrenfeld, "The Conservation of Non-Resources," *American Scientist* 64:648–56 (1976); *The Arrogance of Humanism* (New York: Oxford University Press, 1978), pp. 175–211.
41. Matthew Suffness and John Douros, *supra* note 38.
42. Charles Hartshorne, "The Rights of the Subhuman World," *Environmental Ethics* 1(1):49–60 (1979); Edwin P. Pister, "Endangered Species: Costs and Benefits," *Environmental Ethics* 1:341–52 (1979).
43. Wilderness Act, as amended, 16 U.S.C. § 1131 *et seq.*
44. Endangered Species Act of 1973, as amended, 16 U.S.C. § 1531 *et seq.*
45. National Environmental Policy Act of 1969, as amended, 42 U.S.C. § 4321 *et seq.*
46. Charles S. Elton, *The Ecology of Invasions by Animals and Plants* (London: Methuen & Co., Ltd., 1958), p. 143.
47. David Ehrenfeld, *supra* note 40, at 207–208.
48. Aldo Leopold, "The Round River," in *A Sand County Almanac, supra* note 39, at 90.
49. Edward O. Wilson, *Sociobiology: The New Synthesis* (Cambridge: Belknap Press of Harvard University Press, 1975), p. 379.
50. Paul R. Ehrlich, et al., *supra* note 9, at 124.
51. William E. Odum and Eric J. Heald, "Tropic Analyses of an Estuarine Mangrove Community," *Bulletin of Marine Science* 22:671–738 (1972); Michael P. Weinstein, "Shallow Marsh Habitats as Primary Nurseries for Fishes and Shellfish, Cape Fear River, North Carolina," *Fishery Bulletin* 77:339–57 (1979).
52. William N. Lindall, Jr., John R. Hall, and Carl H. Saloman, "Fishes, Macroinvertebrates, and Hydrological Conditions of Upland Canals in Tampa Bay, Florida," *Fishery Bulletin* 71(1):155–63 (1973); Lee Trent, Edward S. Pullen, and Raphael Proctor, "Abundance of Macrocrustaceans in a Natural Marsh and a Marsh Altered by Dredging, Bulkheading, and Filling," *Fishery Bulletin* 74(1):195–200 (1976).
53. Council on Environmental Quality, *Environmental Quality—1978: The Ninth Annual Report of the Council on Environmental Quality* (Washington, D.C.: U.S. Government Printing Office, 1978), pp. 222–24; *Environmental Quality—1979: The Tenth Annual Report of the Council on Environmental Quality* (Washington, D.C.: U.S. Government Printing Office, 1979), pp. 479–80.
54. Robert A. MacArthur and Edward O. Wilson, *The Theory of Island Biogeography* (Princeton, N.J.: Princeton University Press, 1967), p. 8.

55. James H. Brown, "Mammals on Mountaintops: Nonequilibrium Insular Biogeography," *American Naturalist* 105:467–78 (1971).
56. Richard T.T. Forman, Anne E. Galli, and Charles F. Leck, "Forest Size and Avian Diversity in New Jersey Woodlots with Some Land Use Implications," *Oecologia* (Berlin) 26:1–8 (1975).
57. Clyde D. Barbour and James H. Brown, "Fish Species Diversity in Lakes," *American Naturalist* 108:473–89 (1974).
58. V.J. Tepedino and N.L. Stanton, "Cushion Plants as Islands," *Oecologia* 25:243–56 (1976).
59. Amy Schoener, "Experimental Zoogeography: Colonization of Marine Mini-Islands," *American Naturalist* 108:715–38 (1974).
60. W.J. Freeland, "Primate Social Groups as Biological Islands," *Ecology* 60:719–28 (1979).
61. Jared M. Diamond, "Assembly of Species Communities," in Martin L. Cody and Jared M. Diamond, eds., *Ecology and Evolution of Communities* (Cambridge, Mass.: Belknap Press of Harvard University Press, 1975), pp. 342–444; John Terborgh, "Preservation of Natural Diversity: The Problem of Extinction-Prone Species," *BioScience* 24:715–22 (1974); Edward O. Wilson and Edwin O. Willis, "Applied Biogeography," in Martin L. Cody and Jared M. Diamond, *supra,* at 522–34.
62. Thomas E. Lovejoy and David C. Oren, "Minimum Critical Size of Ecosystems," in R.L. Burgess and B.M. Sharpe, eds., *Forest Habitat Islands in Man-Dominated Landscapes* (New York: Springer-Verlag, 1980); Thomas E. Lovejoy, "Genetic Aspects of Dwindling Populations: A Review," in Stanley A. Temple, ed., *Endangered Birds: Management Techniques for Preserving Threatened Species* (Madison: University of Wisconsin Press, 1978), pp. 275–79.
63. Jared M. Diamond, letter, *Science* 193:1027–1029 (1976).
64. John Terbough, *supra* note 61.
65. Norman Myers, *supra* note 2, at 225.
66. William I. Aron and Stanford H. Smith, "Ship Canals and Aquatic Ecosystems," *Science* 174:13–20 (1971).
67. J.C. Briggs, "The Sea-Level Panama Canal: Potential Biological Catastrophe," *BioScience* 19(1):44–47 (1969).
68. Eric R. Pianka, "On r- and K- Selection," *American Naturalist* 104: 592–97 (1970); Peter L. McCall, "Community Patterns and Adaptive Strategies of the Infaunal Benthos of Long Island Sound," *Journal of Marine Research* 35:221–26 (1977); William J. Platt and I. Michael Weis, "Resource Partitioning and Competition within a Guild of Fugitive Prairie Plants," *American Naturalist* 111:479–513 (1979).
69. Robert F. Whitcomb, James F. Lynch, Paul A. Opler, and Chandler S. Robbins, letter, *Science* 193:1030–1032 (1976).
70. David Sheridan, Council on Environmental Quality, *Off-Road Vehicles on Public Land* (Washington, D.C.: U.S. Government Printing Office, 1979), p. 7.
71. U.S. Fish and Wildlife Service, "Service Lists 32 Plants," *Endangered Species Technical Bulletin* 4(11):1, 5–9 (1979).
72. Daniel S. Hartman, "West Indian Manatee," in Peter C.H. Pritchard, series ed.; James N. Leyne, ed., *Rare and Endangered Biota of Florida,* Vol. 1, *Mammals* (Gainesville: University of Florida Press), pp. 27–30.
73. Robert E. Ricklefs, *Ecology* (Newton, Mass.: Chiron Press, 1973), pp. 758–59.
74. George V. Burger, "Agriculture and Wildlife," in Howard K. Brokaw, ed., *Wildlife and America* (Washington, D.C.: Government Printing Office, 1978), pp. 89–108; Frederic H. Wagner, "Livestock Grazing and the Livestock Industry," *supra,* at 121–49.
75. Paul R. Ehrlich et al., *supra* note 9, at 137.
76. *Id.,* p. 344.

77. P.R. Mooney, *Seeds of the Earth: A Private or Public Resource* (Ottawa: InterPares for the Canadian Council for International Cooperation and the International Coalition for Development Action (London), 1979), p. 3.
78. Donald Ugent, "The Potato," *Science* 170:1161–66 (1970).
79. Noel D. Vietmeyer, *supra* note 6; H. Garrison Wilkes and Susan Wilkes, "The Green Revolution," *Environment* 14(8):32–39 (1972).
80. H. Harrison Wilkes and Susan Wilkes, *supra* note 79.
81. Norman Myers, *supra* note 2, at 61.
82. Hugh H. Iltis, "The Extinction of Species and the Destruction of Ecosystems, Part 2," *American Biology Teacher* 34:201–205 (1972).
83. A. Starker Leopold, "Wildlife and Forest Practice," in Howard K. Brokaw, *supra* note 74, at 108–20.
84. Norman Myers, *supra* note 2, at 115–42.
85. National Academy of Sciences, *Conversion of Tropical Moist Forests* (Washington, D.C., 1980), p. 14.
86. Michael H. Robinson, "Untangling Tropical Biology," *New Scientist* 82:378–81 (1979).
87. Norman Myers, *supra* note 2, at 115–42.
88. Jonathan L. Richardson, "The Organismic Community: Resilience of an Embattled Ecological Concept," *BioScience* 30:465–71 (1980).
89. National Academy of Sciences, *supra* note 85, at 25.
90. R.J.A. Goodland and H.S. Irwin, *Amazon Jungle: Green Hell to Red Desert?* (New York: Elsevier Scientific Publishing Company, 1975), pp. 29–32.
91. Ariel E. Lugo, "Are Tropical Forest Ecosystems Sources or Sinks of Carbon?" in Sandra Brown, Ariel E. Lugo, and Speth Liegel, eds., *The Role of Tropical Forests in the World Carbon Cycle*, CONS–800350–007 (Washington, D.C.: U.S. Department of Energy, 1980), pp. 1–80.
92. Norman Myers, *supra* note 2, at 174.
93. Rachel Carson, *Silent Spring* (Boston: Houghton Mifflin Company, 1962).
94. Patrick W. Borthwick and Steven C. Schimmel, "Toxicity of Pentachlorophenol and Related Compounds to Early Life Stages of Selected Estuarine Animals," in K. Ranga Rao, ed., *Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology* (New York: Plenum Publishing Co., 1978), pp. 141–46; M.E. Tagatz, J.M. Ivey, H.K. Lehman, and J.L. Oglesby, "Effects of a Lignosulfonate-Type Drilling Mud on Development of Experimental Estuarine Macrobenthic Communities," *Northeast Gulf Science* 2(1):35–42 (1978).
95. John Cooper, "The Jackass Penguin," *Marine Pollution Bulletin* 2(4): 52 (1971).
96. Gene E. Likens, Richard F. Wright, James N. Galloway, and Thomas J. Butler, "Acid Rain," *Scientific American* 241(4):43–51 (1979).
97. W. Keller, *Limnological Observations on the Aurora Trout Lakes* (Ottawa: Ontario Ministry of the Environment, 1978), p. 2.
98. Y. Loya, "Recolonization of Red Sea Corals Affected by Natural Catastrophes and Man-Made Perturbations," *Ecology* 57:278–79 (1976).
99. Edward S. Ayensu and Robert A. DeFillips, *Endangered and Threatened Plants of the United States* (Washington, D.C.: Smithsonian Institution and the World Wildlife Fund, 1978), p. 29.
100. Information supplied by John L. Mohr, University of Southern California.
101. Gren Lucas and Jugh Synge, *The IUCN Plant Red Data Book* (Morges, Switz.: International Union for Conservation of Nature and Natural Resources Publications, 1978), pp. 51–52, 305–306.
102. Walter R. Courtenay, Jr., "The Introduction of Exotic Organisms," in Howard K. Brokaw, ed., *supra* note 74, at 237–52.

103. Geerat J. Vermeij, *Biogeography and Adaptation: Patterns of Marine Life* (Cambridge, Mass.: Harvard University Press, 1978), pp. 1–21, 206–42.
104. Clive Roots, *Animal Invaders* (New York: Universe Books, 1976), p. 97.
105. Joseph Connell, "Some Mechanisms Producing Structure in Natural Communities: A Model and Evidence from Field Experiments," in Martin Cody and Jared Diamond, *supra* note 61, at 460–69; Michael L. Smith, "The Status of *Megupsilon aporus* and *Cyprinodon alvarezi* at El Potosi, Nuevo Leon," in Edward P. Pister, ed., *A Summary of the Proceedings of the Tenth Annual Symposium* (Bishop, California: Desert Fishes Council, 1980), pp. 26–29; Thomas M. Zaret and R.T. Paine, "Species Introduction in a Tropical Lake," *Science* 182:449–55 (1973).
106. Charles A. Ely and Roger B. Clapp, "The Natural History of Laysan Island, Northwestern Hawaiian Islands," *Atoll Research Bulletin* 171:1 (Smithsonian Institution, 1973).
107. R.E. Warner, "The Role of Introduced Diseases in the Extinction of the Endemic Hawaiian Avifauna," *Condor* 70:101–120 (1968).
108. Charles S. Elton, *supra* note 46, at 21–24.
109. Beverly Karplus Hartline, "Fighting the Spreading Chestnut Blight," *Science* 209:893 (1980).
110. Clive Roots, *supra* note 104, at 127.
111. Zvi Ben-Avraham, "Accumulation of Stones on Beaches by *Codium fragile*," *Limnology and Oceanography* 16:553–54; M. Dennis Haniśak, "*Codium*: An Invading Seaweed," *Maritimes* 24(3):10–11 (1980).
112. C.B. Huffaker, D.W. Ricker, and C.E. Kennett, "Biological Control of Puncture Vine with Imported Weevils," *California Agriculture* 15(12):11–12 (1961).
113. Walter Courtenay, Jr., *supra* note 102.
114. Executive order 11987, 3 CFR 116 (1978), 42 Fed. Reg. 26949 (1977).
115. Council on Environmental Quality and U.S. Department of State, *supra* note 17, at 327–28.
116. P.R. Mooney, *supra* note 77, at 21.
117. Norman Myers, *supra* note 2, at 221.
118. Peter Steinhart, "Essay—A Proliferation of Islands," *Audubon* 81: 174–75 (1979).
119. *Ibid.*
120. Katherine Ralls, Kristin Brugger, and Jonathan Ballou, "Interbreeding and Juvenile Mortality in Small Populations of Ungulates," *Science* 206:101–103 (1979).
121. National Academy of Sciences, *Conservation of Germplasm Resources: An Imperative* (Washington, D.C., 1978), p. 4.
122. U.S. Fish and Wildlife Service, "Future of Dusky May Depend on Captive Propagation," *Endangered Species Technical Bulletin Special Report,* April 1980.
123. Information supplied by Gerard A. Bertrand, Massachusetts Audubon Society.
124. Endangered Species Act, *supra* note 44.
125. Endangered Species Act Amendments of 1978, Pub. L. 95–632, 92 Stat. 3751.
126. Edward S. Ayensu and Robert A. DeFillips, *supra* note 99, at 71, 94.
127. Convention on International Trade in Endangered Species of Wild Fauna and Flora, *opened for signature* March 3, 1973, 27 U.S.T. 1087, T.I.A.S. No. 8249.
128. Convention on Nature Protection and Wildlife Preservation, in the Western Hemisphere, October 12, 1940, 56 Stat. 1354, T.S. 981, 161 U.N.T.S. 193.

129. 16 U.S.C. § 1362 *et seq.*
130. Interim Convention for the Conservation of Northern Fur Seals of 1957, 8 U.S.T. 2283, T.I.A.S. No. 3948.
131. Convention for the Protection of Migratory Birds, August 16, 1916, United States-Canada, 39 Stat. 1702, T.S. No. 628. This Convention was signed and ratified by Great Britain for Canada.
132. Convention for the Protection of Migratory Birds and Game Mammals, February 7, 1936, United States-Mexico, 50 Stat. 1311, T.S. No. 912.
133. Convention for the Protection of Migratory Birds and Birds in Danger of Extinction, and Their Environment, United States-Japan, March 4, 1972, 25 U.S.T. 3329, T.I.A.S. No. 7990.
134. International Convention for the Regulation of Whaling, December 2, 1946, 62 Stat. 1716, T.I.A.S. No. 1849.
135. Agreement on the Conservation of Polar Bears, November 15, 1973, T.I.A.S. No. 8409.
136. Antarctic Treaty, December 1, 1959, 12 U.S.T. 794, T.I.A.S. No. 4780.
137. Convention Concerning the Protection of World Cultural and Natural Heritage, November 23, 1972, 27 U.S.T. 37, T.I.A.S. No. 8226.
138. Richard K. Yancey, "Implications of International Conventions on Management of Living Resources," in *Transactions of the North American Wildlife and Natural Resources Conference* 45:38–44 (1980).
139. Migratory Species Treaty for Wild Animals, *opened for signature* June 23, 1979, Europ. T.S. No. 104.
140. International Union for Conservation of Nature and Natural Resources, *World Conservation Strategy* (Morges, Switz., 1980), p. 8.

Chapter 3

WATER QUALITY

The nation's surface water—its lakes, wetlands, rivers, and streams—is a visible resource that is intensively used. Less visible and generally of less public concern is the water which lies underground. Nonetheless, ground water is a vital resource that supplies one-quarter of all the fresh water used by industry, in agriculture, and for drinking water in the United States.[1]

Efforts made in the last decade to improve surface water quality are beginning to show results. Data suggest that the quality of surface waters is no longer deteriorating despite continued increases in population and the gross national product. Factories, municipal treatment facilities, and other point sources of pollution are gradually coming under control, although street and farm runoff and other nonpoint sources are often as serious polluters as the point sources of surface water pollution.

Similar efforts to monitor and control ground water quality have not been made primarily because ground water has traditionally been considered very good. But recent data suggest that serious problems exist. There is increasing evidence of ground water contamination by synthetic organic chemicals.

GROUND WATER

Ground water has always been thought of as a pristine resource. But recent information reveals the fact that in many locations ground water is contaminated. Data show that this contamination comes from many different sources and includes a variety of materials, most notably toxic organic and inorganic chemicals. Because ground water is widely used for drinking water, these toxic chemicals are being found in drinking water supplies, and they may be posing unacceptable human health risks.

The discoveries of contamination of ground water by synthetic organic chemicals are particularly disturbing. Their concentrations are often orders of magnitude higher than those found in raw or

treated drinking water drawn from the most contaminated surface supplies, among them the Ohio and Mississippi Rivers.[2] There are no federal health standards for most of the organic compounds found in drinking water wells. Many of the chemicals are known or suspected carcinogens or mutagens which can pose unacceptable human health risks at concentrations on the order of 10 parts per billion and below—levels typical of surface water contamination. Even at concentrations that can cause substantial risk, the compounds are often tasteless and odorless.

Many incidents of ground water contaminated by toxic organic chemicals have recently come to light, for example:

- In 1979, a special Massachusetts Legislative Commission on Water Supply found that at least one-third of the Commonwealth's 351 communities were affected by chemical contamination of drinking water supplies. Private and public wells were restricted or closed in 22 towns. All municipal wells in Groveland and Rowley were closed because of trichloroethylene (TCE) contamination (TCE is known to cause cancer in mice). In North Reading, TCE concentrations exceeded 900 parts per billion (ppb) in two wells supplying 30 percent of the town's water. The state maximum contaminant level is 10 ppb.[3]
- In January 1980, California public health officials closed 37 public wells supplying water to more than 400,000 people in 13 cities in the San Gabriel Valley because of TCE contamination. The pattern of contamination suggests multiple widespread sources of the pollutant. The TCE concentration at one well, now closed, was 600 ppb.[4]
- In 1979, east of Sacramento, TCE concentrations up to 480 ppb were found in 19 rural wells serving private homes and business.[5]
- After 2 years of research, a New York Public Interest Research Group (NYPIRG) released its report documenting the massive ground water contamination problems facing Long Island residents.[6] More than 3 million people in Nassau and Suffolk Counties and in a section of Queens rely on ground water for all uses, domestic and industrial. NYPIRG has documented that all three major aquifers under Long Island are seriously contaminated with effluent from industrial wastes, discharges from municipal treatment plants, and runoff from highways. In addition, agricultural practices and septic tanks have contaminated the ground water. NYPIRG has found evidence of mutagenic substances in ground water at 12 sites on Long Island, including the Syosset and Bethpage municipal landfills and Glen Cover Creek. Many mutagens are also carcinogens.
- In South Brunswick, New Jersey, a family's drinking water well had high concentrations of several chlorinated hydrocarbons, among them: TCE, 1,530 ppb; trichloroethane, 965 ppb; chloroform, 420 ppb; carbon tetrachloride, 400 ppb; xylenes, 300 ppb; toluene, 260 ppb; and benzene, 230 ppb.[7] Several neighbors' wells

also had high concentrations. The ground water contamination arose from a nearby industrial disposal site where tank trucks of waste organic chemicals had been drained into a sandy pit for years.[8]

As a result of these discoveries, federal and state agencies have increased their monitoring efforts, and new data are being produced daily. Most monitoring is concentrated in areas where contamination is suspected, so that it is difficult to generalize about ground water quality nationwide. However, it is clear that a widespread problem exists and that many more cases will be discovered.

A comprehensive, statistically designed monitoring survey for ground waters was recently begun by the Environmental Protection Agency (EPA) to determine the extent of drinking water contamination.

THE RESOURCE—PRESENT USE AND NEW PROBLEMS

Ground water may be defined as subsurface water that occurs beneath a water table in soils or rocks or in geologic formations that are fully saturated.[9] Aquifers, the subsurface permeable formations that can yield significant amounts of water to wells and springs, underlie most of the nation.

Volume and Trends

Ground water is a vast natural resource; its volume is estimated at about 50 times the annual flow of surface water.[10] The Water Resources Council estimates that approximately 36 quadrillion gallons of fresh ground water (more than four times the volume of the Great Lakes) occur within one-half mile of the surface.[11] Rainfall and snow melt recharge ground water at a rate of approximately 300 trillion gallons per year[12] (1 part recharge to 120 parts total volume). In the absence of human intervention, an equal volume of ground water would be returned to the atmosphere, rivers, or oceans and recycled.

Ground water supplies 25 percent of the fresh water used for all purposes in the country.[13] As shown in Table 3–1, approximately 30 trillion gallons of fresh ground water were withdrawn for all uses in 1975—for irrigation, 69 percent; industry, 14 percent; urban drinking water, 13 percent; and rural drinking water, 5 percent. In the 25 years from 1950 to 1975, the use of fresh ground water increased over 140 percent.

The overall amount withdrawn in 1975 was an order of magnitude less than the total natural recharge.[14] In many areas of the arid West, local withdrawals exceeded recharge, thereby creating overdrafts—the long-term reduction of ground water, also called ground water mining. In 1975, approximately 25 percent of all ground water withdrawals were overdrafts, mostly in agricultural regions

of the arid West.[15] Ground water use has increased more rapidly than surface water use.[16] Present withdrawals and possible increased reliance on it (for drinking water and irrigation) show the importance of this valuable resource. (Water supply problems are discussed at length in Chapter 8, Human Settlements and Land Use.)

Table 3–1

Fresh Ground Water Use, 1950–75

Use	Percentage of total			
	1950	1960	1970	1975
Public supplies	12	13	14	13
Rural supplies	8	6	5	5
Irrigation	62	68	66	69
Industry	18	13	15	14
Total withdrawals (trillion gallons per year)	12.4	18.3	24.8	29.9

Totals may not equal 100 because of rounding.

Source: Based on U.S. Environmental Protection Agency, Office of Drinking Water, *Planning Workshops to Develop Recommendations for a Ground Water Protection Strategy: Appendices* (Washington, D.C.: U.S. Government Printing Office, 1980), p. II–3.

Approximately 50 percent of all residents rely on ground water as the primary source of drinking water. Drinking supplies use about 18 percent of the fresh ground water withdrawn each year.[17] Ground water is relied upon for drinking water to different degrees throughout the nation, but more so in rural than in urban areas.[18]

Special Characteristics of Ground Water

Shallow ground water is usually of high quality because soils and soil microbes typically remove most of the contaminants before the water reaches an aquifer. Without contamination by human activity, most shallow and intermediate-depth ground water would meet our intuitive notions for, and legal definitions of, drinking water. Cleansing by filtration and adsorption occurs as the water moves vertically and horizontally. With time, ground water tends toward chemical equilibrium with the minerals that it contacts, thereby increasing its mineral content. Fresh ground water may extend to depths of several thousand feet, but deep strata usually contain highly mineralized water known as brine. In some limited areas, even shallow ground water contains such high concentrations of specific ions or total dissolved solids that it is not fit for human or animal consumption or for irrigation.

Ground water is vulnerable to contamination. Although filtration and adsorption cleanse most pollutants from percolating water, soil

and rock strata do not eliminate all toxic organic chemicals. Plants and microorganisms, for example, do not break down most chlorinated hydrocarbons, a class of resistant, nonbiodegradable, synthetic organic compounds. Moreover, once water reaches a saturated region, very little, if any, further cleansing takes place in a chemically reduced, abiotic, cool, and dark aquifer. Once contaminated, ground water can remain so for hundreds or thousands of years, if not for geologic time.

The degree of threat to ground water depends on the material underlying the surface site and the particular geologic and hydrologic conditions. For example, a dump sited on top of a thick layer of impermeable clay poses little threat to an aquifer beneath it, but a landfill on permeable material is a serious threat. Human activities in recharge areas—siting homes, roads, industry, and waste disposal facilities—will significantly affect the quality of water recharging an aquifer.

Ground water moves very slowly, typically less than a few tens of feet per year, depending on the hydraulic gradient and the permeability of the aquifer. A slug of contaminant moving with the ground water will flow and disperse into a plume, the dimensions of which are controlled by the structure of the aquifer. In time, the contaminants can move great distances. Because of the rate of travel and the vagaries of flow and dispersion, ground water may be heavily contaminated in one place, and only a few hundred feet away it may remain pristine.

There may also be long delays and distances between the time and place of contamination and detection. It may take decades for ground water that was polluted in one place to appear in a water supply elsewhere.

Testing and monitoring are costly. Ground water sampling commonly requires costly test wells and well casings. When ground water occurs in multiple layers between confining rock strata, several isolated wells are needed. In fact, many wells are needed to locate and assess the rate of travel of a plume of contamination in most aquifers. Further assessment of quality requires sophisticated and expensive instrumentation. These measurements must be duplicated and repeated regularly in order to follow migration.

The qualities and quantities of ground and surface waters are interdependent. Fresh water wetlands commonly mark hydrologic connection with both surface and ground waters. Depending on the geology and hydrology of an area, contamination in a wetland or other surface water may pollute an aquifer. Similarly, overdraft of ground water can reduce the dry weather flows in rivers and the water levels in lakes.

HUMAN HEALTH

Risks Associated with Organic Chemicals

No one has argued that organic chemicals in drinking water

benefit human or animal health. At best, some organic chemicals may have no detrimental effects at low concentrations. But many compounds once thought safe—especially synthetic organic chemicals—can have serious and substantial health risks, even in concentrations on the order of 10 parts per billion and below. At even higher concentrations, most of the compounds are tasteless and odorless.

When synthetic organic chemicals, including most if not all chlorinated hydrocarbons, are ingested in food and drinking water, they can cause health problems. At high concentrations and doses (acute exposures), many synthetic organic compounds can cause immediate health problems, such as nausea, dizziness, tremors, and blindness, problems which have not been associated with drinking water. At lower concentrations, at which these compounds become tasteless and odorless, humans may develop skin eruptions or central nervous system impairment. At still lower concentrations, over many months or years (chronic exposures), the compounds can cause health problems, some tolerable and some fatal. With human or animal carcinogens, there is often a long latency period between time of exposure and manifestation of the disease.[19]

EPA Regulation

Many of the light molecular weight chlorinated hydrocarbons measured in drinking water are carcinogens. For example, at low concentrations, trichloroethylene,[20] carbon tetrachloride,[21] tetrachloroethylene,[22] 1,2-dichloroethane,[23] and vinyl chloride[24] have each been shown to cause cancer in humans or in laboratory animals. Medical and scientific evidence suggests that these compounds have no safe levels or thresholds of exposure—that is, they cannot be consumed through air, food, or water without risk of adverse health effects.[25]

The toxicity associated with simultaneous or sequential exposures to several of these compounds is unknown. Basic scientific studies on the effects of toxic chemicals suggest that two toxic compounds present simultaneously may have antagonistic, additive, or synergistic effects on an organism.[26] It is plausible that multiple exposures have additive risks associated with them. To date, in the case of human exposure to synthetic organic chemicals in drinking water, there is no direct evidence of additive effects.

Under the Safe Drinking Water Act of 1974, the Environmental Protection Agency can establish national standards—maximum contaminant levels (MCLs)—for pollutants in drinking water from community water supplies.[27] In 1975, EPA promulgated interim final MCLs for six pesticides: toxaphene, methoxychlor, endrin, lindane, 2,4-D, and 2,4,5-T.[28] In addition, EPA promulgated an interim final MCL for the trihalomethanes.[29] Trihalomethanes result primarily from the interaction of chlorine (used as a disinfectant) with the natural organic substances present in raw water. The

trihalomethanes interim final MCL applies to community water systems supplying more than 10,000 people. Monitoring for trihalomethanes is to begin in November 1980 for water systems serving over 75,000 people.

For most of the compounds that frequently contaminate well water, EPA has not yet proposed MCLs, although some states have adopted standards for a few compounds. One difficulty, of course, is the potentially large number of compounds to be considered. For a few compounds the EPA Office of Drinking Water has prepared interim nonbinding guidelines, Suggested No Adverse Response Level (SNARL) documents, for use by states and municipalities on a case-by-case advisory basis.[30] Each SNARL is based on a numerical model calculation of the likely human health risks extrapolated from laboratory data on animal health effects.[31]

EPA will replace the interim SNARLs with standards (MCLs) for trichloroethylene, 1,1,1-trichloroethane, tetrachloroethylene, carbon tetrachloride, 1,2-dichloroethane, and vinyl chloride in the near future.[32] Additional MCLs will be provided later.

SOURCES OF CONTAMINATION

Contamination of ground water from human activities may come from surface impoundments, landfills, agriculture, leaks and spills, land disposal of waste waters, septic tanks, mining, petroleum and natural gas production, underground injection wells, and other sources, as shown in Figure 3–1.

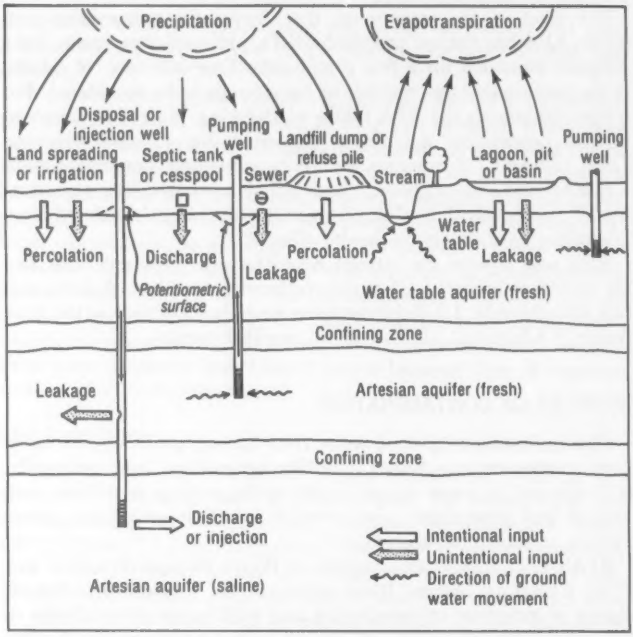
EPA's 1977 *Report to Congress on Waste Disposal Practices and Their Effects on Ground Water* identified the disposal of industrial wastes at industrial impoundments and solid waste disposal sites as the most important source of ground water contamination.[33] EPA estimated that approximately 57 million of the 378 million tons of liquid and solid industrial wastes generated in 1978 were hazardous.[34] Most hazardous wastes are disposed of in landfills or lagoons in ways that do not meet new federal standards and thus are a threat to ground water quality.[35]

In addition to industrial wastes, the 1977 *Report* identified secondary sources of national importance: septic tanks, municipal waste water, mining, and petroleum exploration and production. Although concentrations of toxic materials for these sources are lower than for industrial waste disposal, they can be significant regionally.

EPA has attempted to rank contamination sources by region. In the Northeast, Southeast, and Northwest—areas with substantial manufacturing activity and high population densities—industrial wastes and domestic sewage disposal have the largest impacts on ground water. In areas where mining and petroleum production are concentrated, these activities cause the most commonly reported contamination problems.[36]

Figure 3-1

Sources of Ground Water Contamination



Source: U.S. Environmental Protection Agency, Office of Water Supply and Solid Waste Management Programs, *Waste Disposal Practices and Their Effects on Ground Water: Executive Summary* (Washington D.C.: U.S. Government Printing Office, 1977), p. 8.

Industrial Landfills and Lagoons

There are no firm data even on the total number of land sites for disposal of industrial wastes. The number of active industrial landfills has been estimated at 75,700.[37] Some 50,644 active and inactive sites may have potentially dangerous amounts of hazardous wastes.[38]

The Surface Impoundment Assessment,[39] funded by EPA and conducted by the states, identified 25,749 industrial impoundments in a total of 176,647 impoundments. Because of the hazardous nature of much of the wastes placed in industrial impoundments, the states performed detailed assessments of industrial sites. Preliminary analyses of 8,163 indicate that:

- In 50 percent the liquid wastes may contain hazardous substances

- In 70 percent there is no lining, possibly allowing contaminants to enter the ground beneath
- For 95 percent there is no ground water monitoring system to detect toxic contamination.[40]

In a separate analysis of the chemicals and allied products industry, 35 percent of the impoundments contained potentially hazardous wastes.[41]

Test results confirm that a high proportion of industrial landfills do contaminate ground water. A 1977 study[42] of 50 industrial disposal sites found organic contaminants, including PCBs, chlorinated phenols, benzene and its derivatives, and organic solvents, in the ground water at 40 sites and migration of the chemicals at 27 sites. Heavy metals were found at 49 sites and were confirmed to have migrated at 40. Selenium, arsenic, or cyanide was present at 37 sites and had migrated at 30. None of the 50 sites had reported contamination prior to this special study.[43]

Municipal Landfills

A 1978 *Waste Age* survey identified more than 14,000 active municipal landfills; only 35 percent were in compliance with state regulations.[44] There is no good estimate of the number of abandoned or closed municipal dumps and landfills, although it could be comparable. There are no estimates of ground water contamination from abandoned, closed, or operating municipal dump and landfill sites, but the new EPA regulations issued under the Resource Conservation and Recovery Act[45] require re-examination of all operating facilities, complete with ground water measurements.

Septic Tanks and Onsite Sewage Disposal

Approximately 19.5 million housing units in the United States use onsite disposal systems.[46] Some operate well; some do not. Through leaching fields these systems discharge more than 1 trillion gallons of waste into the ground each year.[47] Septic tanks and cesspools rank highest in total volume of waste water discharged directly to ground water and are the most frequently reported sources of fecal, toxic, and other contamination. Septic discharges often contaminate private wells.

Ground water contamination has been documented in communities such as those in the Northeast and California with high densities of septic tank units[48] (see Table 3–2). The problem is magnified by the fact that in many areas—especially rural communities—the prevalance of septic tanks is paralleled by reliance on private wells for drinking water.

Table 3–2

Counties with More Than 50,000 and 100,000 Housing Units Using Onsite Domestic Waste Disposal Systems

More than 50,000	More than 100,000
Jefferson, Alabama	Los Angeles, California
Riverside, California	Dade, Florida
San Bernadino, California	Nassau, New York
Fairfield, Connecticut	Suffolk, New York
Hartford, Connecticut	
New Haven, Connecticut	
Broward, Florida	
Duval, Florida	
Hillsborough, Florida	
Jefferson, Kentucky	
Bristol, Massachusetts	
Middlesex, Massachusetts	
Norfolk, Massachusetts	
Plymouth, Massachusetts	
Worcester, Massachusetts	
Genesee, Michigan	
Oakland, Michigan	
Monmouth, New Jersey	
Multnomah, Oregon	
Westmoreland, Pennsylvania	
Davidson, Tennessee	
King, Washington	
Pierce, Washington	

Source: U.S. Environmental Protection Agency, Offices of Water Supply and Solid Waste Management Programs, *Waste Disposal Practices and Their Effects on Ground Water: Executive Summary* (Washington, D.C.: U.S. Government Printing Office, 1977), p. 23.

A septic tank with a soil absorption field can provide low-cost, reliable treatment for normal household waste water if the unit is properly sited, designed, built, and operated. On a regular schedule of every year or two, a septic tank requires cleaning, usually with a large suction unit mounted on a truck, to remove the accumulated sludge from the bottom. Otherwise, sludge prevents treatment of the waste water and allows pathogenic microorganisms to contaminate the ground water.

In most areas, homeowners can buy septic tank cleaning fluids, most of which contain trichloroethylene (TCE), benzene, or methylene chloride. A gallon or less of the fluid, when flushed down a toilet, dissolves the sludge in a septic tank so that it flows into the soil absorption field. This practice causes two types of severe ground water contamination. The sludge itself is a contaminant, but more important, TCE is a known animal carcinogen. TCE and other chlorinated organic solvents spread with the ground water. An estimated 400,000 gallons of these septic tank cleaners were used by homeowners in 1979 on Long Island alone. As a result, widespread

ground water contamination has contributed to the closure of many public and private drinking water wells.[49]

Mining and Petroleum Production

There are many active coal, metal, and nonmetal mines in the United States. Most mines are a threat to water quality. In many mining areas, ground water contamination is an accepted fact of life. Contamination is caused not only by waste disposal facilities, such as slurry lagoons, tailings ponds, and slag piles but also by the failure to reclaim mined land. The Surface Impoundment Assessment identified approximately 25,000 mining impoundments.[50]

The national effort to replace some imported fossil fuels with domestic synthetic fuels could pose environmental risks, including risks to ground water quality, unless adequate protection accompanies development. If the synfuel industry adopts in-situ (underground) retorting of oil shale without proper environmental safeguards, ground water contamination could occur.[51]

Activities related to petroleum production have caused substantial contamination in the south central and southwest states. Although no full account of the problem is available, 17 states have documented ground water contamination from this source.[52] In Texas alone, 23,000 cases of ground and surface water contamination caused by petroleum activity have been reported.[53] Brine pits to dispose of the saline byproducts of drilling are now almost universally banned by the states. Nevertheless, 80 years of using brine pits has limited the use of ground water in many areas. EPA's Surface Impoundment Assessment has identified nearly 65,000 active petroleum production impoundments, more than twice the number of other industrial impoundments.[54] Abandoned and poorly maintained producing and injection wells are also potential contamination sources.

GROUND WATER CONDITIONS AND TRENDS

Availability of Data

There are no national synoptic data on ground water contaminants, the number of persons exposed, or the health effects sustained because this problem has only recently come to public attention. Most of what is known comes from intensive local studies and anecdotal reports.

With some exceptions, data on ground water quality gathered by the states and the U.S. Geological Survey do not generally focus on the problems of hazardous waste disposal and contamination by synthetic organic chemicals. Whether case study data are representative of the full range of water quality problems is not known because virtually every case study to date has examined only a few of several hundred possible compounds—and then only where

contamination was suspected. In some areas, re-analysis showed high concentrations of toxic substances not even looked for the first time.

Laboratory identification and measurement of organic contaminants are much improved in the last few years. But the techniques are difficult, costly, sometimes capable of producing highly variable results, and sensitive to interferences from other compounds. For several important classes of nonvolatile organic compounds, there are no agreed-upon methods for isolation and detection, much less measurement.[55]

Although the effort to learn how and where synthetic organic chemicals have contaminated ground water is small, it is growing. It is known that ground water has been contaminated with significant concentrations of both natural and synthetic toxic chemicals. Arsenic, barium, and radionuclides in toxic concentrations are often related to the natural soils, whereas contamination by synthetic organic chemicals is generally associated with where they are made, spilled, used, or discarded.

Much of the present knowledge comes from research teams following hot spots of serious contamination. In May 1980, EPA and state agencies had many such projects underway, but data from these efforts vary in specificity, quality, and coverage.

The National Perspective

The water supplies of 39 cities drawing on ground water have been tested to determine the frequency of raw and treated drinking water contamination by volatile chlorinated solvents (other than trihalomethanes). All the cities and towns had populations above 1,000, and most of the data are for cities of 10,000–1,000,000. The results of these measurements for 11 chlorinated hydrocarbons are shown in Table 3–3. One of the chemicals found most frequently was trichloroethylene, a widely used solvent and degreaser which has produced cancer in mice.[56] TCE was found equally often in raw and treated water samples, although concentrations are generally lower in treated water. Tetrachloroethylene was found more often and in higher concentrations in treated water than in raw water. The source of, or the mechanism which produces, this chemical is not known.

Some states have begun vigorous testing programs for a few synthetic organic chemicals in drinking water wells. Because most states focus on hot spots, values are higher than in the federal surveys of the 39 cities.

As of March 1980, state agencies had made more than 8,000 chemical measurements of only volatile organic compounds from hundreds of wells[57] (see Table 3–4). Again trichloroethylene was the most frequently detected compound. Other chlorinated hydrocarbons, including tetrachloroethylene, 1,1,1-trichloroethane, 1,1-dichloroethane, and dichloroethylene were also found frequently, some at very high concentrations, i.e., above 1,000 parts per billion.

Table 3–3

Concentrations of Selected Synthetic Organic Compounds in Raw and Finished Ground Water

(micrograms per liter = parts per billion)

Compound	Number of cities sampled		Percentage with chemical present		Concentration					
					Mean		Median		Range	
	Raw	Fin	Raw	Fin	Raw	Fin	Raw	Fin	Raw	Fin
Trichloroethylene	13	25	38.5	36.0	29.72	6.76	1.3	0.31	0.2–125.0	0.11–53.0
Carbon tetrachloride	27	39	7.4	28.2	11.5	3.8	11.5	2.0	3.0– 20.0	0.2 –13.0
Tetrachloroethylene	27	36	18.5	22.0	0.98	2.08	0.6	3.0	0.1– 2.0	0.2 – 3.1
1,1,1-Trichloroethane	13	23	23.1	21.7	4.8	2.13	1.1	2.1	0.3– 13.0	1.3 – 3.0
1,1-Dichloroethane	13	13	23.1	23.1	0.7	0.3	0.8	0.2	0.4– 0.9	0.2 – 0.5
1,2-Dichloroethane	13	25	7.7	4.0	0.2	0.2	NA	NA	0.2– NA	0.2 – NA
Trans-dichloroethylene	13	13	15.4	15.4	1.75	1.05	1.75	1.05	0.2– 3.3	0.2 – 1.9
Cis-dichloroethylene	13	13	38.5	30.8	13.56	9.35	0.1	0.15	0.1– 69.0	0.1 –37.0
1,1-Dichloroethylene	13	13	15.4	7.7	0.5	0.2	0.5	NA	0.5– 0.5	0.2 – NA
Methylene chloride	27	38	3.7	2.6	4.0	7.0	NA	NA	4.0– NA	7.0 – NA
Vinyl chloride	13	25	15.4	4.0	5.8	9.4	5.8	NA	2.2– 9.4	9.4 – NA

NA = Not applicable.

Source: U.S. Environmental Protection Agency, Office of Drinking Water, "The Occurrence of Volatile Organics in Drinking Water," briefing paper, March 6, 1980.

Table 3–4

Organic Compounds Found in Ground Water as Reported by the States

(micrograms per liter = parts per billion)

State	Number of wells tested	Percentage of wells with chemical present								
		Trichloro-ethylene	Carbon tetra-chloride	Tetra-chloro-ethylene	1,1,1-Tri-chloro-ethane	1,2-Dichloro-ethane	1,1-Dichloro-ethane	Dichloro-ethylenes	Methylene chloride	Vinyl chloride
Alabama	80	10	0	4	10	3	8	10	0	1
Connecticut	1,200	2	NM	NM	NM	NM	NM	NM	NM	NM
Delaware	19	79	NM	NM	NM	73	NM	NM	56	NM
Florida	329	NM	50	20	15	15	36	38	1	16
Idaho	9	11	NM	11	11	NM	NM	NM	NM	NM
Kentucky	22	0	5	0	0	0	0	0	NM	0
Maine	89	0	0	0	18	0	0	0	0	0
Massachusetts	163	36	0	19	21	3	1	8	2	NM
New Hampshire	6	17	0	0	0	NM	NM	NM	NM	NM
New Jersey	411	27	23	11	48	2	NM	NM	0	0
New York	372	13	5	15	9	NM	NM	NM	NM	NM
North Carolina	44	18	0	5	2	7	14	45	18	34
Rhode Island	88	22	0	NM	NM	NM	NM	NM	NM	NM
South Carolina	4	0	0	0	0	25	0	50	0	0
South Dakota	1	0	0	0	NM	0	NM	NM	NM	NM
Tennessee	50	14	8	2	26	8	26	26	8	6
Virginia	1	100	NM	NM	NM	NM	NM	NM	NM	NM
Washington	6	33	NM	33	66	0	0	NM	0	0
Maximum concentration	NM	35,000	379	50	2,250	400	11,330	860	3,600	380

NM = No measurements taken.

Source: U.S. Environmental Protection Agency, Office of Drinking Water, "The Occurrence of Volatile Organics in Drinking Water," briefing paper, March 6, 1980.

Several of these compounds have been shown to cause cancer in laboratory animals, usually rats or mice (see the earlier section of this chapter on human health).

New York—One State's Experience

New York has one of the nation's most comprehensive and sophisticated programs for ground water monitoring. Through its program, New York has learned of major problems, and state and local officials have begun remedial and preventive measures.[58]

After synthetic organic chemicals were discovered in some public water supply wells in Nassau County in 1976, state and county agencies analyzed water from all wells used for community water supplies. Water was tested for only six synthetic organic chemicals: tetrachloroethylene, 1,1,2-trichloroethylene, chloroform, 1,1,1-trichloroethane, carbon tetrachloride, and trifluorotrichloroethane. The results are shown in Table 3–5.

Table 3–5

Organic Chemicals Detected in Community Water Supply Wells, Nassau County, 1978

(micrograms per liter = parts per billion)

Contaminant	Number of wells tested	Number of wells positive	Percentage positive	Maximum concentration detected
Tetrachloroethylene	372	57	15	375
1,1,2-Trichloroethylene	372	50	13	300
Chloroform	372	41	11	67
1,1,1-Trichloroethane	372	33	9	310
Carbon tetrachloride	372	20	5	21
Trifluorotrichloroethane	372	4	1	135

Source: Nancy K. Kim and Daniel W. Stone, *Organic Chemicals and Drinking Water* (Albany: New York State Department of Health, 1980), p. 9.

Sampling for organic chemicals began in Suffolk County about the same time. By December 1978, the analysis of 500 wells was complete.[59] As a result, 23 community water wells in Nassau County and 13 in Suffolk County were closed. Neither lost all its wells, but more than 2 million people were affected. Shortfalls from closures were made up from other wells, but in an area which relies almost exclusively on ground water for all purposes, the closures caused a number of substantial dislocations.[60]

In 1978, the New York State Health Department and the U.S. Geological Survey (USGS) began to study ground water supplies for 112 organic chemical contaminants elsewhere in the state. Thirty public water systems were sampled and a total of 47 samples was taken from 39 wells. Every well tested contained some contamination

by synthetic organic chemicals. The 10 most common contaminants are shown in Table 3–6. The industrial chemicals bis (2-ethylhexyl) phthalate, toluene, and di (n-butyl) phthalate were found in 92, 85, and 54 percent, respectively, of the wells sampled.

Bedford and Gray—The Experience of Two Small Towns

In recent years, many small towns and single families have lost ground water supplies to contamination. There is no way of knowing how many people were affected or how they managed. Two examples—towns with fewer than 15,000 people—are Bedford, Massachusetts, and Gray, Maine.

Table 3–6

The 10 Synthetic Organic Compounds Most Commonly Detected in Public Water System Wells in New York State, 1979

(micrograms per liter = parts per billion)

Contaminant	Number of wells tested	Number of wells positive	Percentage positive	Maximum level detected
Bis(2-ethylhexyl)phthalate	39	36	92	170.0
Toluene	39	33	85	10.0
Di (n-butyl) phthalate	39	21	54	470.0
Trichloroethylene	39	18	46	19.0
Ethylbenzene	39	17	44	40.0
Diethyl phthalate	39	13	33	4.6
Trichlorofluoromethane	39	11	28	13.0
Anthracene/phenanthrene	39	7	18	21.0
Benzene	39	6	15	9.6
Butyl benzyl phthalate	39	5	13	38.0

Source: Nancy K. Kim and Daniel W. Stone, *Organic Chemicals and Drinking Water* (Albany: New York State Department of Health, 1980), p. 11.

In May 1978, four of Bedford's wells, which provide 80 percent of the town drinking water, were found to be contaminated with toxic organic chemicals, including up to 2,100 parts per billion of dioxane and up to 500 ppb of TCE. Officials do not know how long the water had been contaminated. The discovery was wholly accidental, the result of a resident engineer's testing the water for a paper that he was writing. Upon learning of it, local officials closed the wells.

Bedford responded to the crisis by restricting water use, instituting an increasing block rate water structure, and banning new water connections. The community also purchased water from four neighboring towns, until one of them closed two of its main wells because of trichloroethylene contamination. The cost of buying water from outside sources has placed a large financial burden on Bedford.

In addition, the costs of engineering studies of the contaminated areas are high.[61]

In Gray, Maine, 16 private drinking water wells were closed in 1977 after it was discovered that they were contaminated with toxic organic chemicals. All were located near an industrial waste handling facility built in 1972 to process waste oil from the *Tamano* oil spill in Casco Bay. From then until 1977, the McKin Company used the facility as a transfer station. Materials were mixed, stored in tanks, and shipped to refiners. Approximately 100,000–200,000 gallons were processed annually at the Gray site.

Wastes spilled at the processing facility leached into the ground water. Unpleasant tastes and offensive odors were reported in drinking water from private wells nearby. The well water even discolored laundry. Although samples were tested at the state laboratory, the contaminants were not identified. The residents then turned to alternate sources of water, eventually extending the town pipeline.

In 1977, trichloroethane, trichloroethylene, freon, acetone, xylene, dimethyl sulfide, and various alcohols were identified in eight private wells within 2,000 feet of the McKin Company. Gray's health officer ordered 16 contaminated wells in the area capped, and the McKin facility was ordered closed.[62]

POLICIES AND PROGRAMS

The Federal Legal Framework

The Congress has assigned some ground water protection responsibilities, most notably to the Environmental Protection Agency and to the Department of the Interior, including the U.S. Geological Survey. The laws passed over the years include, for EPA, the Clean Water Act,[63] the Safe Drinking Water Act,[64] the Resource Conservation and Recovery Act,[65] and the Toxic Substances Control Act [66] and, for Interior, the Surface Mining Control and Reclamation Act.[67] Some parts of the laws overlap, leading to duplication of effort. Taken together, these laws do not cover all types of situations, and there are gaps in the laws and rules even with state efforts to protect ground water.

The most important federal laws affecting ground water contamination are described below.

In the 1972 Federal Water Pollution Control Act and its 1977 amendments,[68] the Congress gave EPA the major responsibility to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." [69] The Congress directed the Administrator to "prepare or develop comprehensive programs for preventing, reducing, or eliminating the pollution of the navigable waters and ground waters." [70] EPA has undisputed authority over nearly all major programs concerning "navigable waters." The close hydrologic connection between many, if not all, surface and ground waters

further supports EPA authority over ground water.[71] In one case in which the hydrologic connection was clear, a U.S. District Court upheld EPA's mandate to require state promulgation of ground water quality standards.[72]

EPA has not exercised its authority or pressed for programs to protect ground water quality under the 1972 and 1977 laws.[73] Only recently has EPA begun to use the Clean Water Act's Section 208 areawide planning program provisions to address nonpoint sources of much ground water contamination.[74] EPA has also used its authority under Section 311 of the Act to control hazardous spills.[75]

The Safe Drinking Water Act of 1974 [76] extended federal regulation of drinking water supplies to all community supplies. EPA is responsible for establishing both drinking water quality standards and, as needed, for requiring application of specific water treatment technologies. Protection of ground water quality is the direct concern of the Underground Injection Control (UIC) Program [77] and the sole source aquifer designation provisions of the Gonzales Amendment.[78]

Subtitle C of the Act, designed to prevent "endangerment" of "underground drinking water" sources, directs EPA to establish minimum requirements for state regulation of discharges from deep waste injection wells into ground water.[79] EPA recently published its final regulations in the *Federal Register*.[80] Although the Act and the regulations define endangerment somewhat differently, both refer to a violation of national (interim) primary drinking water standards as a definitive indicator of "endangerment."[81] The underground injection regulations allow for classification of aquifers into those which are or are not underground drinking water sources.[82] They offer limited protection to those which are officially classified as drinking water sources and none to those which are not.

The Safe Drinking Water Act allows EPA to designate an aquifer the sole or principal source of drinking water for an area. After such designation by the EPA Administrator, "no commitment for Federal financial assistance . . . may be entered into for any project which the Administrator determines may contaminate such aquifers through a recharge zone so as to create a significant hazard to public health."[83] By July 1980, seven aquifers had been designated "sole source," and eight petitions were under consideration.[84]

The Resource Conservation and Recovery Act of 1976 [85] assigns EPA major duties and provides tools for regulation of the disposal of municipal and hazardous industrial wastes. EPA's approach is based on point source regulation and technology rather than on ground water quality or performance standards.

EPA has almost completed promulgation of the regulations on municipal and hazardous wastes under the Act. If new source standards were applied retroactively to operating and abandoned municipal and industrial waste disposal sites, it is fair to say that only a small fraction would pass.

With the standards that EPA has promulgated for new and continuing waste disposal sites, disposal methods will be more in keeping with hydrologic theory. But the illegal and improper disposal of hazardous wastes, such as "midnight dumping," may be more common as legal waste disposal sites become scarce and more costly to operate.

The Toxic Substances Control Act (TSCA),[86] also passed in 1976, gives EPA new responsibilities for regulating the manufacture, use, and disposal of toxic substances. The statute explicitly recognizes that the disposal of many synthetic chemicals presents unreasonable risks to people and to natural resources, including air and water quality. TSCA clearly gives EPA authority to control the disposal of most, if not all, of the toxic organic chemicals now found in ground water supplies. Because of the size and complexity of the regulatory task, EPA is behind in implementing the waste disposal and other provisions of the Act. (See Chapter 5, Toxic Substances.)

The Surface Mining Control and Reclamation Act,[87] passed in 1977 to regulate coal mining, creates an Office of Surface Mining in the Department of the Interior. The Office has authority to issue operating permits, mining and reclamation plans, and reclamation bonds for coal surface mining operations. Both surface and deep coal mining have caused serious and substantial pollution of aquifers with acids and heavy metals. The Act has strict provisions for the prevention of chemical contamination and hydrologic disruption of ground water.

The State Legal Framework

Each state has one or more laws pertaining to ground water contamination. Commonly, several parties—a health department, an environmental protection agency, and state engineers—share responsibility for drinking water and other ground water uses. There are untold variations in state regulatory systems for ground water quality and quantity management.

Two neighbors, New York and New Jersey, are among the states with comprehensive ground water protection laws. In each, the state legislature has empowered an administrative agency to classify ground water, to establish water quality standards for a small number of categories, and to promulgate rules for point source effluents (municipal and industrial) discharged into ground water in each category. The New Jersey legislation has a general nondegradation clause for ground water.[88]

The New York state program, administered by the Department of Environmental Conservation, classifies ground water as GA (fresh water), GSA, and GSB (both salt water). For GA aquifers, the "best use" is drinking water; for GSA aquifers, the "best use" is potable mineral waters, conversion to fresh drinking waters, or raw material in the manufacture of table salt; and for GSB waters, the "best use" is receiving waters for disposal of wastes. For GA waters, the Department sets maximum contamination concentrations for 83 pollu-

tants, including heavy metals and toxic organic compounds,[89] and stringent effluent standards for wastes discharged into GA ground water. The state has a general provision for nondegradation, but its legal status is unclear.

SURFACE WATER

CONDITIONS AND TRENDS

In some localities there has been substantial improvement in water quality, but the quality of surface waters nationally has not changed much in the last 5 years. The fact that the nation's surface water has not deteriorated despite a growing population and an increased gross national product is an accomplishment for control efforts.

Although it appears that large-scale degradation of surface waters has been stopped, water quality data indicate that pollution from some conventional and toxic pollutants is still widespread. Concerted efforts to control toxic pollutants have only just begun. Similarly, programs to manage urban and agricultural runoff and other nonpoint sources are just beginning. Even control of point source municipal and industrial discharges, which has been underway for several years, is not yet complete. For example, of the 5,623 municipal sewage treatment projects begun since 1972, only 1,552 were in operation as of December 1979.[90] These facts underscore the point that cleaning up the nation's water takes a long time. It is not surprising, then, that vast improvements are not yet evident. The full effect of pollution control efforts will not be seen for a few more years.

Rivers and Streams

National Trends Using U.S. Geological Survey (USGS) data and EPA water quality definitions, the Council analyzed six key pollution indicators in rivers and streams. The results suggest little or no change nationally from 1975 through 1979. For four of the six pollution indicators—fecal coliform bacteria, total phosphorus, lead, and mercury—violations of EPA criteria for safe swimming or preservation of aquatic life remain frequent and widespread.

CEQ analyzed data from the National Stream Quality Accounting Network (NASQAN), which maintains strategically located stations throughout the nation. At each site a broad range of variables is measured on a systematic and continuing basis, and uniform methods are used for data collection and analysis. Although many NASQAN stations are located near the mouths of relatively large rivers and streams and provide data that are not wholly representative of the nation's streams, no other data-gathering network has sufficient uniform and consistent data available for analysis of national conditions and trends for 1975 through 1979 (improvement of environmental data and monitoring is discussed below).

From the 547 NASQAN monitoring stations, CEQ selected 309 for analysis, using only those "primary" stations which had data for the entire period and did not change location during the time. Stations designated "secondary" because they monitor water quality at sites which USGS considers nonrepresentative of the region were not included.

The analysis is based on monthly measurements of fecal coliform bacteria, dissolved oxygen, and total phosphorus and on quarterly measurements of total cadmium, total lead, and total mercury. For each, CEQ determined annual median concentrations for 1975–79 and annual violation rates (the percentage of measurements exceeding threshold levels, shown in Table 3–7), and analyzed the data to gain insight into national conditions and trends. The results are shown in Figures 3–2 to 3–7.

Table 3–7

Thresholds Used in the CEQ Analysis of National Surface Water Quality

Pollution Indicator	Symbol	EPA threshold level
Fecal coliform bacteria	FC	200 cells/100 ml [a]
Total phosphorus	TP	0.1 mg/l [b]
Dissolved oxygen	DO	5.0 mg/l [c]
Total cadmium	Cd	4.0 μg/l for soft water [d] 10.0 μg/l for hard water [e]
Total lead	Pb	exp [(1.51 ln (hardness) — 3.37)] [f]
Total mercury	Hg	0.05 μg/l [g]

l = liter; ml = milliliter; mg = milligram; μg = microgram.

[a] EPA criteria level for "bathing waters." There is no uniform national standard for FC concentrations in water used for swimming; standards vary with use and locality. State standards sometimes differ from nationally recommended criteria.

[b] Value discussed by EPA for "prevention of plant nuisances in streams or other flowing waters not discharging directly to lakes or impoundments."

[c] EPA criteria level for "good fish populations."

[d] EPA criteria level for preservation of aquatic life less sensitive than cladocerans and salmonid fishes for water with $CaCO_3$ concentrations of up to 75 mg/l.

[e] Because the EPA *Redbook* criteria level for preservation of the less sensitive aquatic life for water with over 75 mg/l $CaCO_3$ concentration is 12 μg/l, CEQ has chosen to use the more stringent criteria level "for domestic water supply (health)."

[f] A 1979 EPA proposed criteria level for preservation of aquatic life.

[g] EPA criteria level for preservation of "freshwater aquatic life and wildlife."

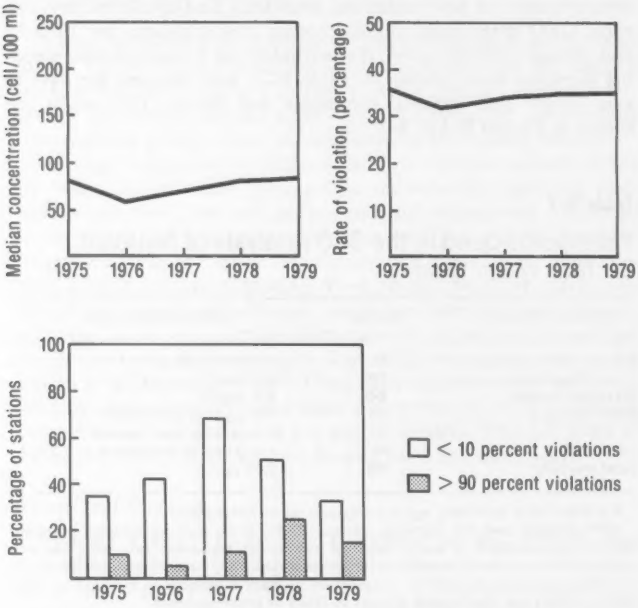
The EPA *Redbook* is: U.S. Environmental Protection Agency, *Quality Criteria for Water* (Washington, D.C.: U.S. Government Printing Office, 1976).

Fecal Coliform Bacteria (FC) Counts of fecal coliform bacteria are a common sanitary engineering measure of water pollution produced by the feces of warm-blooded animals. Such pollution usually arises from improperly treated human sewage, street runoff, combined sewer overflows in urban regions, feedlots and grazing lands in agricultural areas, and wildlife.

As Figure 3–2 indicates, the national median concentration of fecal coliform bacteria—as measured at the NASQAN sites—fluctuates between 1975 and 1979, but it shows no overall change. Similarly, there is no overall change in the violation rate.

Figure 3-2

Fecal Coliform Bacteria, 1975-79



Source: CEQ analysis of U.S. Geological Survey and U.S. Environmental Protection Agency data.

Although the figure shows that the national median has consistently remained well below 200 cells per milliliter, the criteria level set for bathing waters, many individual measurements exceed this level. As measured at the NASQAN sites, the national violation rate has been about 35 percent each year.

The number of individual locations with high or low violation rates is irregular from year to year. A detailed analysis of the data at individual locations suggests that some of the very worst water may be improving slightly and some of the very best water may be deteriorating slightly.

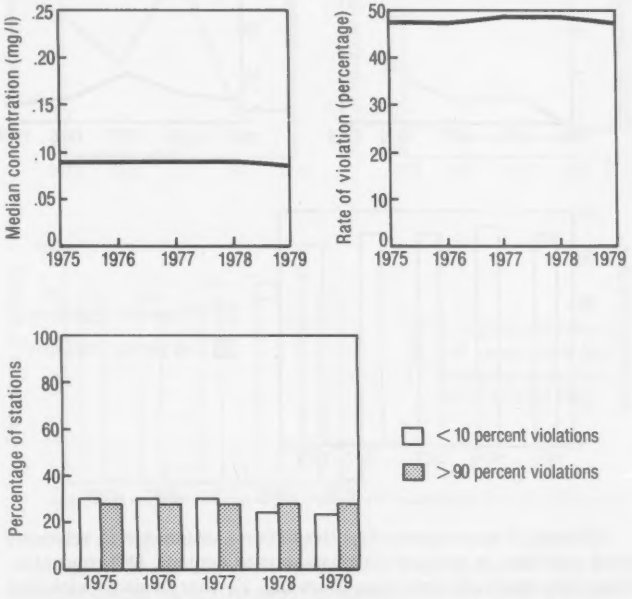
Total Phosphorus (TP) Phosphorus, a nutrient essential to all plant growth, can trigger noxious algal blooms, especially in fresh water. High levels are generally the result of human activity. In agri-

cultural areas, phosphorus in fertilizers can run off fields during rain storms or when erosion occurs. In urban areas, phosphorus can be discharged in municipal sewage, both from human wastes and from phosphates in laundry detergents. Some municipal treatment plants can remove most of the phosphorus, but most cannot.

As Figure 3–3 shows, for 1975–79, the median concentration of phosphorus at NASQAN monitoring sites has remained slightly below 0.1 milligrams per liter (mg/1), a goal for the prevention of plant nuisances in streams or other flowing waters not discharging directly into lakes or impoundments. But many measurements exceed this concentration; for the nation, it has been nearly 50 percent each year. Over the 5 years, both the median concentration and the rate of violation show little change. Further analysis suggests that the number of monitoring sites with poor water quality is not changing, and the number with good water quality may be decreasing slightly. (A 1979 EPA analysis covering a longer time period and using a different data base found improved phosphorus concentrations in rivers and streams in the Great Lakes region.[91])

Figure 3-3

Total Phosphorus, 1975-79



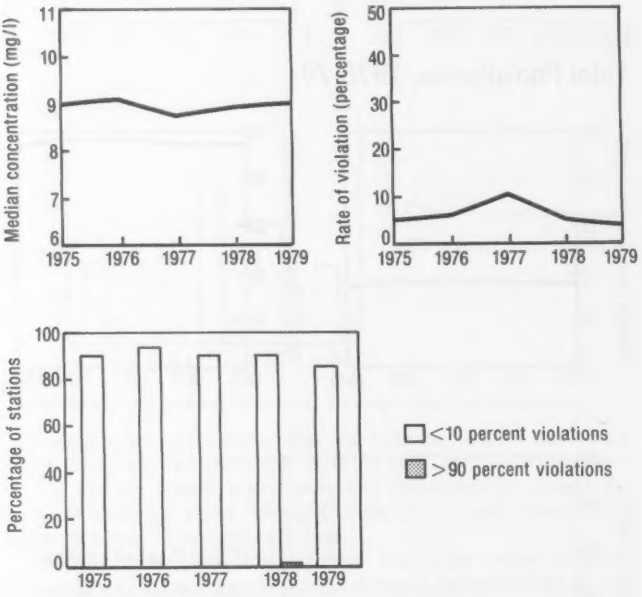
Source: CEQ analysis of U.S. Geological Survey and U.S. Environmental Protection Agency data.

Dissolved Oxygen (DO) The amount of oxygen dissolved in water is one measure of the ability of water to support aquatic animal life. It is affected by natural processes and many water pollutants. Depressed DO levels most often occur where there are large amounts of decaying organic matter from natural sources or human disturbances such as sewage effluents.

Figure 3–4 shows that dissolved oxygen levels at NASQAN monitoring sites demonstrate no overall change from 1975 through 1979. Of the total number of measurements, about 5 percent have been below 5 mg/l, the criteria level for good fish populations. This relatively low national violation rate applies to individual stations as well. Over 90 percent of the locations have had less than 10 percent violations in all years; hardly any locations analyzed had 90 percent violations in any of the years.

Figure 3-4

Dissolved Oxygen, 1975-79



Source: CEQ analysis of U.S. Geological Survey and U.S. Environmental Protection Agency data.

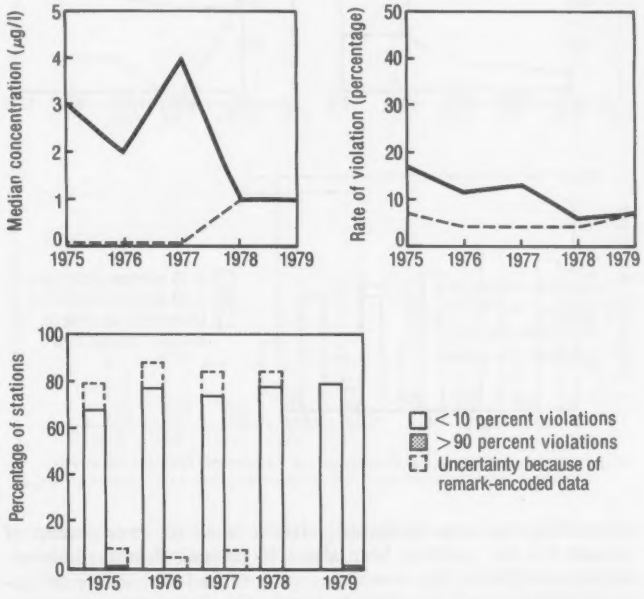
Although it may appear that the nation's waters are in relatively good condition in terms of dissolved oxygen content, DO concentrations vary seasonally and even diurnally. Further, a single violation can kill all the fish in a stream.

Cadmium (Cd), Lead (Pb), and Mercury (Hg) Cadmium, lead, and mercury are very toxic heavy metals. Natural concentrations of each are normally quite low.

Concentrations of total cadmium, total lead, and total mercury are difficult to determine. Because their concentrations are frequently below the detection limits of measuring equipment, data are often reported simply as "less than" a given value. These data are referred to as "remark-encoded" data.

In Figures 3–5, 3–6, and 3–7, the solid lines in the charts are based on the assumption that the actual values for remark-encoded data are the same as they would be without the remark. The dotted lines in the charts are based on the assumption that the actual values of remark-encoded data are zero. Therefore the true values in Figures 3–5, 3–6, and 3–7 lie somewhere between the solid line and the dotted line.

Figure 3-5
Total Cadmium, 1975-79

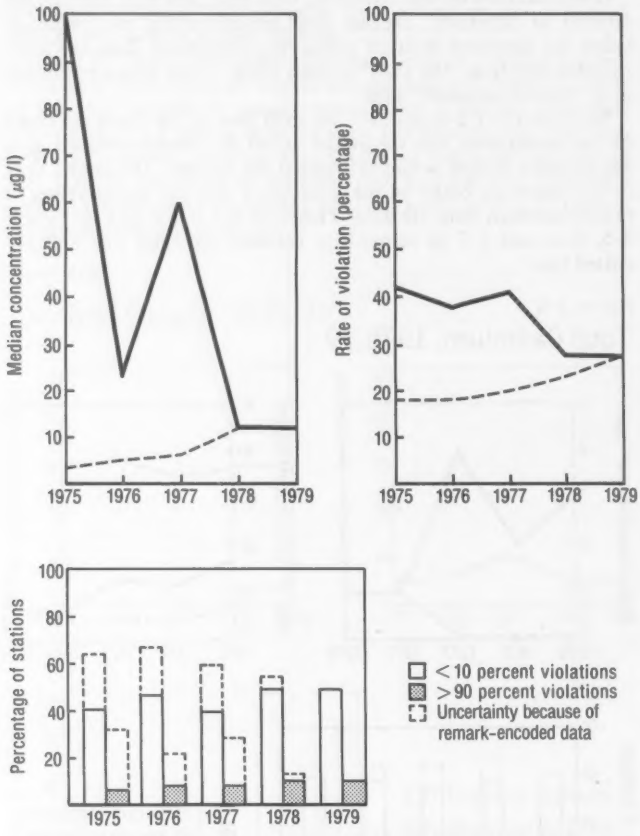


Source: CEQ analysis of U.S. Geological Survey and U.S. Environmental Protection Agency data.

Although trends cannot be determined from available data, some conclusions can be drawn about conditions. Of the total number of cadmium measurements, the number exceeding either 4 or 10 μg/l

Figure 3-6

Total Lead, 1975-79



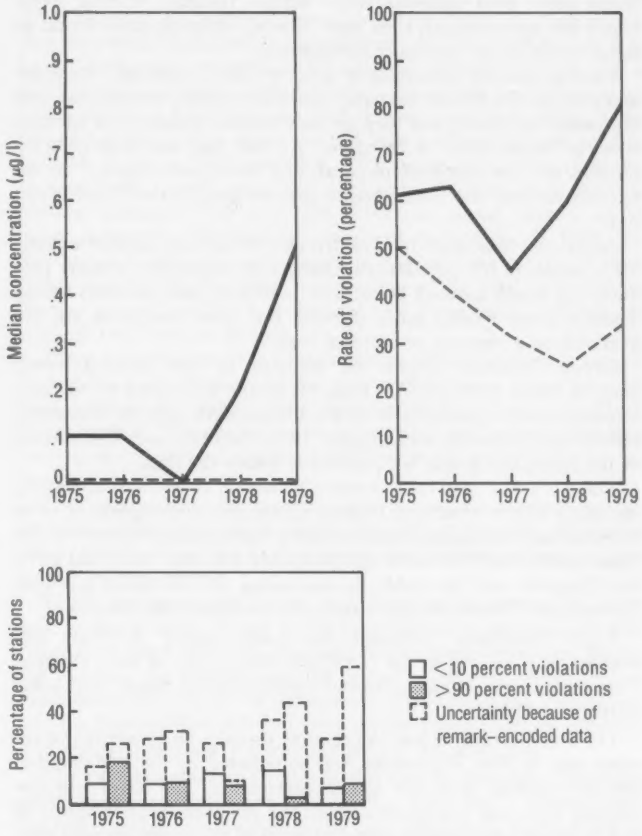
Source: CEQ analysis of U.S. Geological Survey and U.S. Environmental Protection Agency data.

(depending on water hardness), criteria levels for preservation of aquatic life, has probably been about 10 percent. Further, approximately one-fifth of the monitoring stations had violation rates exceeding 10 percent, but almost none had violation rates exceeding 90 percent.

It should be noted that the criteria level used for cadmium violation rates was the less stringent of two established for the preservation of aquatic life. If the more stringent criteria level were used (for the

Figure 3-7

Total Mercury, 1975-79



Source: CEQ analysis of U.S. Geological Survey and U.S. Environmental Protection Agency data.

preservation of cladocerans and salmonid fishes), the violation rate would be considerably higher.

Nationwide, lead and mercury violation rates have been approximately 25 percent and 50 percent, respectively. For lead, about one-half the NASQAN monitoring stations had less than 10 percent of measurements above the threshold level, and the number of sites with a low violation rate substantially exceeded those with a high violation rate, as shown in Figure 3–6. For mercury the number of sites

is roughly equal for low and high violation rates, although there is also considerable uncertainty in the mercury data.

Criteria levels for preservation of aquatic life are used in these violation rates. Had domestic water supply (health) criteria levels, which are less stringent, been used instead, violation rates would be significantly lower, especially for mercury.

Finding suitable indicators of water quality is difficult. Measurements of fecal coliform bacteria, dissolved oxygen, phosphorus, and the metals are useful, but they are only indirect measures of whether water is "swimmable" or "fishable." At best, they are incomplete indicators of "the chemical, physical, and biological integrity" of the nation's waters—the water quality goal set forth in the Clean Water Act.

Additional indicators such as diversity of fish and smaller aquatic life, changes in fish populations, changes in vegetation, primary productivity, beach closings because of pollution, and bioassays would describe water quality more directly. But these indicators are not available on a regional or national basis.

Urban Pollution Trends In addition to the national trends analyses based on NASQAN data, CEQ also attempted to examine trends in water quality for 31 cities. This analysis requires consistent, reliable data showing water quality both upstream and downstream of the cities, but it was not possible to locate the data.

There is a real need for systematic collection of water quality data, including intensive surveys, both upstream and downstream of cities where sewage treatment plants are being constructed. Not only would these data be useful to water quality trends, but they would aid EPA, the Congress, and the public in evaluating the $4 billion per year Construction Grants Program and other pollution control efforts.

Local Conditions Although the water quality in rivers and streams, as measured at the NASQAN sites, seems to have changed little nationwide, it has improved significantly in many local areas during the 1970s.

The Pemigewasset River, which runs through an important recreation area in New Hampshire, was so polluted by the mid-60s that few fish survived in it and tourists spurned it. The River was discolored, ugly, and malodorous. With the pollution control efforts of both industry and municipalities, 55 miles of the River are now suitable for fishing and swimming.[92]

In 1971, the Hackensack River in New Jersey was officially declared a "highly disturbed and truncated ecosystem" that was "virtually dead." Many of the fish, shellfish, and crustaceans that had thrived in it for thousands of years had disappeared in just 40 years. The River was full of garbage and rusting cars, and there were industrial oil slicks. After an intensive 5-year cleanup effort, the Hackensack Meadowlands Development Commission reported in 1976 that the River was coming back to life. Ribbed mussels were introduced, and they have survived. Blue crabs are in abundance. Water-

fowl and shore and wading birds are now common along the banks, and stripers, alewife, and herring have returned.[93]

In 1973, the Texas Water Quality Board ranked the Neches Tidal Area as the second most polluted waterway in the state in terms of effort necessary to restore water quality. The Board also determined that two main industrial concentrations—chemical plants on Star Lake Canal and a complex of oil refineries, chemical plants, and a fertilizer manufacturer on Mobil Canal—could best meet water quality standards by tying into two central waste treatment plants being planned. Construction began in 1974, and both plants were on line in 1976. Between 1974 and 1976, EPA issued permits to 16 major industrial and 7 major municipal discharging facilities on or near the Neches. Between 1974 and 1978, EPA also issued permits to 51 minor industrial and 14 minor municipal dischargers. In 1976, the first tarpon in 30 years was caught in Sabine Lake on the Neches. Other aquatic life has been reappearing in the tidal areas of the Neches as well; shrimp are plentiful and commercial crabbers are working the River for profit.[94]

These examples are only a few of many showing local water quality improvement throughout the nation. Of course, there are also local areas where water quality is deteriorating. One is the Duck River basin in Tennessee, where phosphate mining and chemical companies are causing increased pollution problems in the River, including fish kills.[95]

The water quality improvements mentioned above relate to conventional pollutants such as oxygen-demanding materials, suspended solids, and bacteria. But in many areas toxic substances may require special control efforts.

Toxic Substances in Rivers and Streams Awareness of water quality degradation caused by toxic substances is growing. Several rivers have been seriously affected by toxic pollutants—the James, the Hudson, the Shenandoah, the Susquehanna, the Delaware, the Housatonic, the Coosa, the Shiawassee, the Mobile, the Tombigbee, and the Holston Rivers.[96] Pesticides, hydrocarbon products, solvents, acid residues, and heavy metals are among the pollutants.

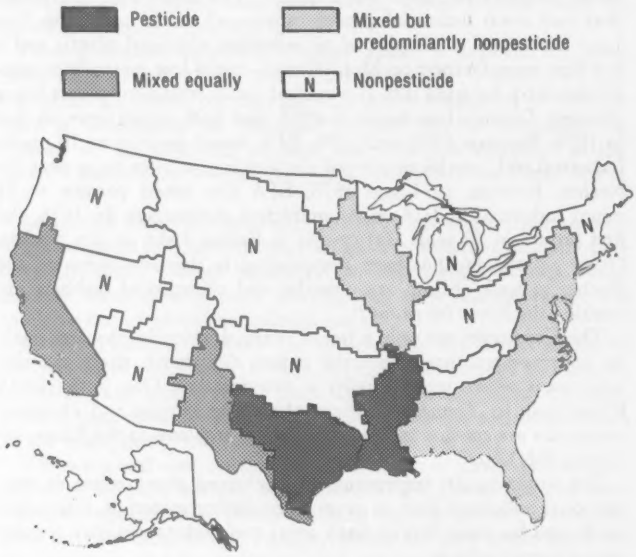
The 1978 State Water Quality Reports to the Congress, submitted under the Clean Water Act, revealed that 35 of the 37 states reporting had a problem with pollution by toxic substances. But the lack of monitoring data for most toxic substances makes it impossible to estimate how widespread the problems are or to say whether conditions are improving or deteriorating.

According to the states, the most widely reported toxic substances problem is contamination by heavy metals. They have been reported in rivers and streams throughout the nation. In California, for example, mercury concentrations exceeding EPA guidelines were detected in fish from five rivers in 1978.[97]

Pollution of rivers and streams by pesticides is a serious problem. Of the states reporting, more than one-half (19) reported pesticide

Figure 3-8

Pesticide- and Nonpesticide-Related Water Pollution, 1978



Source: U.S. Environmental Protection Agency, Office of Water Regulations and Standards.

pollution. As Figure 3–8 shows, toxic water pollution problems of the south central states are largely caused by pesticides. But there is some evidence of improvements following restrictions on pesticide use. In Arkansas, for example, concentrations of DDT in rivers and streams have gradually decreased.[98]

Pollution from cyanides, phenols, polychlorinated biphenyls (PCBs), and other industrial chemicals was also reported by more than one-half (19) the states reporting. The problems may be considerably more widespread than these figures indicate because wide-scale monitoring for many organic toxic pollutants has only recently begun. Phenolic compounds were identified as water pollution problems in 11 states, 12 chemical production areas, and the upper Ohio River Basin.[99] Polychlorinated biphenyls (PCBs) were reported as problems in eight states; as a result, fishing was restricted in parts of the Hudson and Housatonic Rivers, and fish consumption bans or warnings were issued in Connecticut, New York, Michigan, and other states.[100]

Two widely publicized cases of toxic substances contamination of rivers were the discoveries of Kepone in the James River in Virginia and PCBs in the Hudson River in New York. From 1975 to 1980, the Kepone contamination of the James has resulted in sport and commercial fishing losses estimated at about $20 million,[101] and the PCB contamination of the Hudson has caused sport and commercial fishing losses estimated in the millions of dollars annually from 1976 to 1980.[102] In both instances, as in numerous others, the accumulation of chemicals in river-bottom sediments and the nondegradability of the substances suggest that the contamination may well remain for years.[103]

Lakes

Surface waters include not just rivers and streams but lakes as well. Their quality is determined largely by the quality of feeder streams and by disposal of wastes and other local land use practices, soil erosion, and runoff of fertilizers and pesticides from farmlands and gardens.

The water quality of lakes is also affected by airborne pollutants through both precipitation and dry fallout on the lake surface. Acid rain is seriously damaging hundreds of U.S. lakes (see Chapter 4, Air Quality). Through atmospheric transport and deposition, nutrients as well as heavy metals, PCBs, and other toxic substances are also known to contaminate lakes.

Perhaps the most widespread lake pollution problem is eutrophication. Eutrophication usually begins with increased production of plants. As they die, settle to the bottom, and decay, they use the dissolved oxygen in the water and gradually fill in the lake. When polluted discharges provide excessive nutrients, the natural process of eutrophication is accelerated. Human activity in a lake's watershed can accelerate this process. Eutrophication from human activity—"cultural" eutrophication—can produce nuisance blooms of algae, kill fish by depleting dissolved oxygen, and render the water unfit for recreation.

Because lake water quality has received relatively little attention from EPA and from state and local agencies, very little systematic monitoring has been done. Consequently, there are no national data for the study of trends.

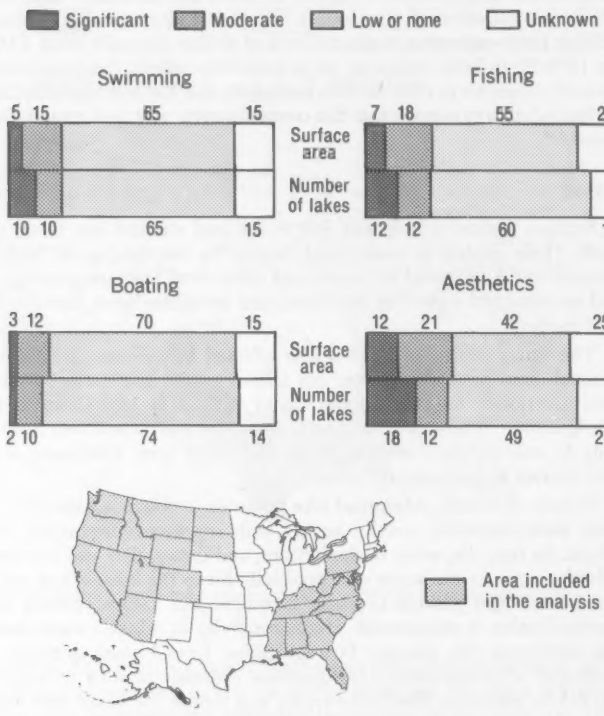
Some qualitative evaluations are available, however. As part of its environmental profile effort, EPA asked state agencies to assess all large lakes of 10 or more square miles and some smaller lakes that are important for recreation. Swimming, fishing, boating, and aesthetics were evaluated for each lake.

As Figure 3–9 indicates, for the 400 lakes evaluated, conditions of most lakes permit at least one of the four uses. Aesthetics is the most widely impaired use, with at least 30 percent of the lakes at least moderately impaired. For swimming and for fishing, at least 20–25

Figure 3-9

Lake Water Impairment

(percentage)



Source: CEQ analysis of U.S. Environmental Protection Agency Regional Profiles, 1978.

percent of the lakes are at least moderately impaired. Boating is the least impaired use.

In the Great Lakes, serious water quality problems were identified by the International Joint Commission (IJC) in 48 areas in 1978; they are shown in Figure 3–10. Some of the problems identified were caused by toxic or hazardous substances, but most related to phosphorus, suspended solids, or biochemical oxygen demand.

As described in the 1979 Annual Report, the 1972 Great Lakes Water Quality Agreement between Canada and the United States emphasized eutrophication and the control of phosphorus discharges.[104] The Agreement was updated and the serious problem of

Figure 3-10

Degraded Water Quality Areas of the Great Lakes, 1978

Source: Great Lakes Water Quality Board, *Great Lakes Water Quality: Seventh Annual Report [1978] to the International Joint Commission* (Windsor, Ontario: International Joint Commission, Great Lakes Regional Office, 1979), p. 20.

toxic and hazardous substances emphasized in a new 5-year agreement in 1978.[105] To meet conditions of the new agreement, the two governments set tentative goals for the amount of phosphorus entering each Lake each year (see Table 3–8). The goals are based on mathematical models relating water quality to phosphorus entering a Lake or on specific programs to control phosphorus sources.[106]

In 1978, the amount of phosphorus exceeded the Agreement goal for all the Lakes. Although Lake Superior received a larger quantity of phosphorus in 1978 than in 1976 and 1977, the generally high quality of open waters in the Lake did not change.[107] Lake Michigan, still considered oligotrophic—that is, of good quality—has deteriorated somewhat in the 3 years studied, although phosphorus concentrations in the southern basin of the Lake decreased somewhat between 1976 and 1977.[108] Most of Lake Huron is oligotrophic, except for some nearshore areas, including Saginaw Bay.[109] In Lake Erie total phosphorus concentrations have essentially not changed since 1970,[110] and although the phosphorus load has decreased substantially in the last 10 years, it is still more than 75 percent above the 1978 Agreement goal. The amount of phosphorus entering Lake Ontario increased somewhat in 1978, although phosphorus concentrations appeared to be dropping during 1977 and 1978.[111] In overall trophic conditions, however, there appeared to be no general improvement noted in the lower Great Lakes.

Table 3–8

Phosphorus Loadings of the Great Lakes, 1978 and Proposed

(metric tons per year)

Basin	1978 Inputs	Goals
Lake Superior	5,990	3,400
Lake Michigan	6,245	5,600
Lake Huron	5,197	4,360 •
Lake Erie	19,464	11,000
Lake Ontario	10,943	7,000

• Total of four sub-basins of Lake Huron.

Sources: International Joint Commission, Surveillance Subcommittee, *Great Lakes Water Quality, 1978: Seventh Annual Report* (Windsor, Ontario: International Joint Commission, Great Lakes Regional Office, 1979); U.S. Department of State, *1978 Great Lakes Water Quality Agreement* (Washington, D.C.: International Joint Commission, 1978).

The 1978 amendments to the Great Lakes Water Quality Agreement renewed emphasis on toxic and hazardous substances, especially persistent organic contaminants, entering the Lakes. In 1978, for example, the concentration of PCBs—a class of toxic chlorinated hydrocarbons now generally banned in the United States—still exceeded the Agreement objective of 0.1 microgram per gram ($\mu g/g$) (whole fish).[112] The discovery of previously undetected chemicals in the Great Lakes will probably continue as laboratory and analytical capabilities are refined.

Concentrations of DDT in Great Lakes fish generally continue to decline and, for most fish, are below Agreement goals. The concentration of dieldrin, a related pesticide which is also banned for most uses in the United States, appears to be declining in Lake Michigan coho salmon, but it is almost double the acceptable value in other species.[113] The persistence of dieldrin in fish and herring gulls shows that it may take a long time before concentrations decline to the limit of detection. Mirex, another persistent toxic pesticide, was primarily found in fish taken from Lake Ontario.[114]

Mercury contamination is still a problem in several of the Lakes. Whitefish, lake trout, and suckers along the northern shore of Lake Superior had mercury concentrations above the Agreement goal.[115] In Lake Erie waters, total mercury concentrations in the eastern basin frequently exceeded the objective of 0.2 $\mu g/g$. Although concentrations in most Lake Erie fish have declined in the last few years, the values still exceed the goals.[116]

Estuaries and Coastal Waters

An estuary is a semi-enclosed body of water—a bay, a lagoon, or the mouth of a river—in which fresh and salt waters meet and mix.

Along the thousands of miles of the nation's coasts, there are many estuaries, some large and some small. Estuaries are critical to the food chain of many species of life.

The Council has compiled a new data base on estuaries using the EPA STORET water quality file. The data include many water quality indicators in estuaries on the Atlantic, Pacific, and Gulf coasts for the 1970s. Data were analyzed in terms of the threshold values shown in Table 3–9.

The CEQ analysis suggests that, overall, estuarine conditions are not changing radically. One finding of the analysis is that the conductivity of water in some estuaries has increased. Apparently a change of some kind is taking place, but its cause and its significance for the ecological vitality of the estuaries are not known.

In some estuaries, changes have been taking place for the conventional indicators—biochemical oxygen demand (BOD), fecal coli-

Table 3–9

Thresholds Used in the CEQ Analysis of National Estuary Water Quality

Pollution indicator	Symbol	EPA threshold level
Conductivity	COND	NA
Turbidity	TURB	NA
Salinity	SAL	NA
Chlorides	Cl	NA
Biochemical oxygen demand	BOD	5 mg/l [a]
Fecal coliform bacteria	FC	14 cells/100ml [b]
Chlorophyll a	Chl a	NA
Nitrates	NO_3	10 mg/l [c]
Total kjeldahl nitrogen	TKN	40 mg/l [c]
Phosphates	PO_4	1 mg/l [a]
Total phosphorus	TP	1 mg/l [a]
Total cadmium	Cd	1 µg/l [d]
Total lead	Pb	10 µg/l [a]
Total mercury	Hg	0.1 µg/l [f]
Total arsenic	As	29 µg/l [d]
Total chromium	Cr	25 µg/l [d]
Total copper	Cu	5 µg/l [d]
Total zinc	Zn	25 µg/l [a]

l = liter; ml = milliliter; mg = milligram; µg = microgram.

NA = Not applicable.

[a] Value chosen by CEQ because relatively high concentration of this indicator is not critical to estuaries.

[b] EPA criteria level for "shellfish harvesting waters."

[c] Value used in the absence of an EPA *Redbook* or proposed criteria level and chosen by CEQ after discussions with EPA about a reasonable value to use.

[d] EPA proposed criteria level for preservation of aquatic life in estuarine waters.

[e] Value used in the absence of an EPA *Redbook* or proposed criteria level and chosen by CEQ after discussions with EPA about a possible final criteria level value.

[f] EPA criteria level for preservation of aquatic life in marine waters.

The EPA *Redbook* is: U.S. Environmental Protection Agency, *Quality Criteria for Water* (Washington, D.C.: U.S. Government Printing Office, 1976).

form bacteria, nitrates, total nitrogen, phosphates, and total phosphorus. For nitrates and total nitrogen the changes are in both directions—improvement in some estuaries and degradation in others. Where BOD, fecal coliform bacteria, phosphates, and total phosphorus concentrations have changed, they have been improving.

Of the conventional indicators, only fecal coliform bacteria concentrations generally exceed the threshold level in some of the estuaries.

Little change is observable among the heavy metals. Except for high lead concentrations in the Jacksonville area, lead, arsenic, and chromium appear to pose no problem to estuaries, as judged against the threshold levels. Cadmium concentrations tend to be high along the east coast, zinc in the Southeast and Gulf, and copper in many places. (Copper concentrations are naturally high in estuarine waters. The average natural concentration of copper in sea water is about 3.0 $\mu g/1$;[117] the threshold level is 5.0 $\mu g/1$.) Mercury concentrations may be high in the Northeast, but the data are uncertain.

Another indication of the quality of coastal waters is closure of shellfish harvesting areas because of pollution. Figure 3–11 shows their status in 13 coastal states.

Because state standards, harvesting areas, and reporting systems differ, the states should not be compared by these data. The figure does show that 9 of the 13 states had at least 20 percent of their active shellfish harvesting waters closed at all times. For the 13 states combined, 26 percent of the total shellfish area was closed to commercial harvesting at all times, another 4 percent open only conditionally.

Drinking Water

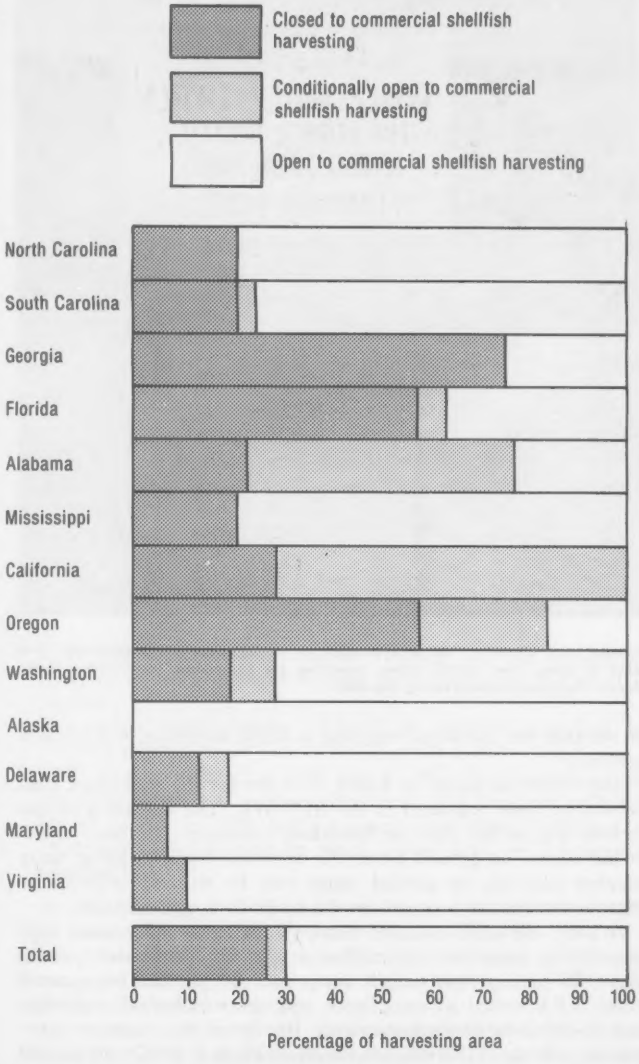
Under the Safe Drinking Water Act,[118] EPA has issued National Interim Primary Drinking Water Regulations.[119] The NIPDWR, which went into effect in June 1977, set maximum allowable contamination levels for microbiological contaminants, turbidity, and chemical-radiological contaminants. There are MCLs for more than 20 chemicals or organisms. The regulations also require monitoring for these contaminants.

In 1978, EPA received the first data from the required monitoring. They related only to microbiological contaminants. The data showed that some 10–20 percent of the community water supplies in the United States, serving about 3 percent of the population, failed to comply with the microbiological standards.[120]

In 1979, the microbiological sampling was repeated, and monitoring was extended to 10 inorganic contaminants. As Figure 3–12 shows, approximately 20 percent—a total of 11,300 systems—reported one or more violations during the year. About 60 percent of the failures to comply were in very small systems, serving fewer than 500 people—systems which often lack adequate skilled labor for satisfactory operation. With only 1 year's data, there is no indication

Figure 3-11

Status of Active Shellfish Harvesting Areas, 1977-79



Source: U.S. Environmental Protection Agency Regional Profiles.

Sebago Lake, Portland, Maine. Protection of public water supplies varies from state to state; even within states, practices are sometimes inconsistent (Peter Morelli, Portland, Maine, *Evening Express*).

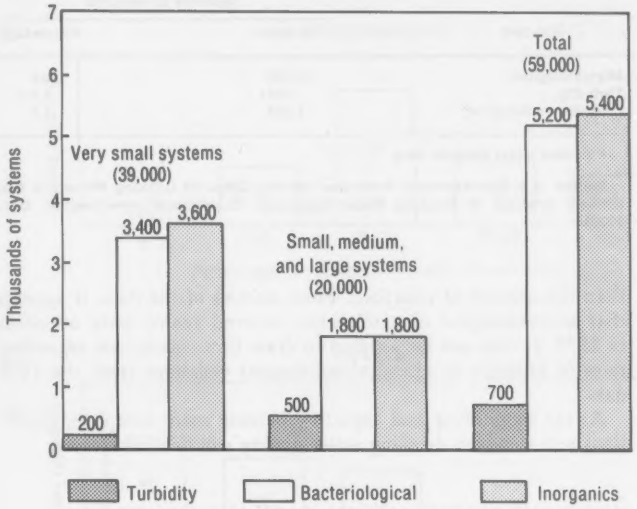
of whether the violations represent a single incidence or a chronic problem.

The violations shown in Figure 3–12 are for the traditional contaminants, those regulated in the NIPDWR. The violations do not include any of the toxic or hazardous substances discussed earlier in the section on ground water. As discussed there, drinking water supplies that rely on ground water may be seriously affected by organic contaminants as well as the traditional contaminants.

In early 1980, EPA studied nearly 62,000 community water supplies serving more than 200 million people. Of these water systems, about 20 percent use surface water and 80 percent use ground water. EPA looked at compliance with microbiological, turbidity, and chemical-radiological standards. Results of the study on compliance with the NIPDWR are shown in Table 3–10. Of the 62,000 systems,

Figure 3-12

Estimated Number of Water Supply Systems in Violation of Federal Drinking Water Standards, 1979



Source: U.S. Environmental Protection Agency, "Community Water Systems: Financial Aspects of Compliance with Interim Primary Drinking Water Regulations," draft, January 31, 1980.

- 6,745 community water systems violated the microbiological standard in 1979—a slight increase over 1978, from 9.3 to 10.9 percent
- 760 surface water systems violated the turbidity standard in 1979—a slight increase over 1978, from 6.0 to 6.8 percent
- 1,007 systems violated at least one of the chemical-radiological standards in 1979. Chemical-radiological data were not collected for all systems in 1978, but the sample was valid. Violations in 1978 were about 10 percent, much higher than the 1.6 percent reported in 1979.

As shown in Figure 3–13, the percentage of MCL violations in 1979 varies. Some states reported violation rates of up to 67 percent. Compared with 1978, microbiological violations in 1979 are about equal, turbidity violations are slightly higher, and chemical-radiological violations are lower.

More than one-third of the states reported no violations, especially for turbidity and chemical-radiological MCLs. This apparent conformance may be a function of incomplete monitoring rather

Table 3–10

Compliance with Maximum Allowable Contamination Levels, 1979

Standard	Systems in violation	
	Number	Percentage
Microbiological	6,745	10.9
Turbidity	760 [a]	6.8 [a]
Chemical-radiological	1,007	1.6

[a] Surface water systems only.

Source: U.S. Environmental Protection Agency, Office of Drinking Water, "A Preliminary Analysis of Drinking Water Regulation Compliance" (Washington, D.C., 1980).

than the absence of violations. From analysis of the data, it appears that microbiological contamination received major state attention in 1979. It may not be justified to draw firm conclusions regarding rates of turbidity or chemical-radiological violations from the 1979 data.

As the monitoring and reporting become more complete, conditions and trends in drinking water quality will become clearer.

IMPROVING ENVIRONMENTAL DATA AND MONITORING

There are many problems associated with water quality data and assessment of national conditions and trends—data sparsity, nonrepresentative monitoring sites, limited detection capability for some pollutants, and uncertain data quality.

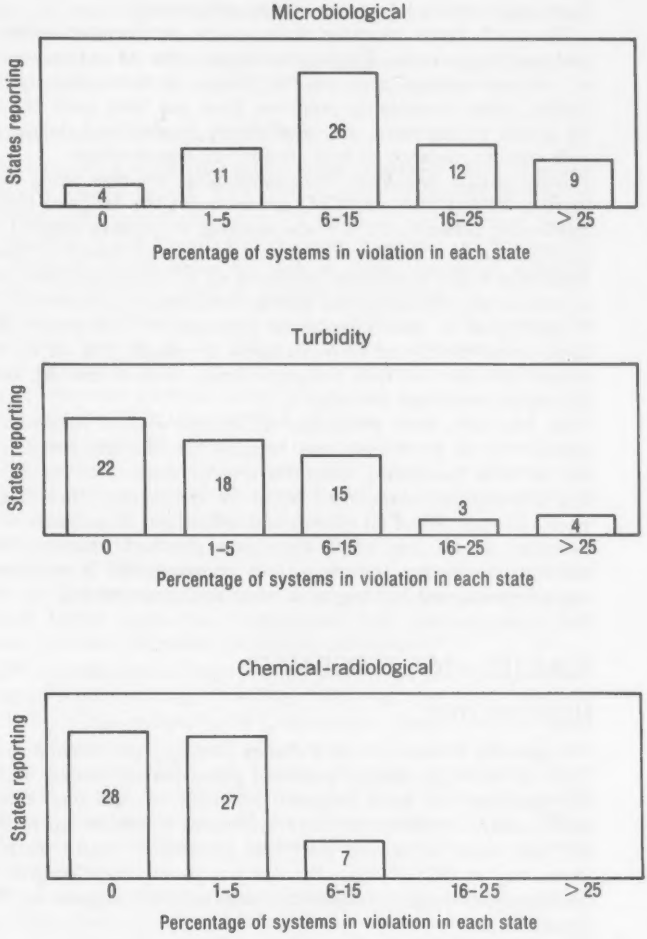
EPA is evaluating the design of water quality monitoring networks to ensure that the data collected represent what they are intended to represent. Because water quality is the result of complex, dynamic processes, current fixed-station monitoring networks with monthly or quarterly measurements can miss important changes in water quality; on the other hand, they can record a condition that is in fact a quirk of sample timing or is peculiar to a given site.

Another problem is data validity. Quality assurance is only beginning to be implemented in water quality monitoring programs. Further, every datum has some degree of uncertainty associated with it. That degree of uncertainty could be reported along with the datum to ensure its proper use. To date, water quality data are collected, reported, and used with no indication of their quality and precision.

The President called attention to these deficiencies, among others, in his 1977 Environmental Message.[12] He directed CEQ to establish an interagency task force to review environmental data and

Figure 3-13

Number of States[a] Reporting Water Supply Systems in Violation of Federal Drinking Water Standards, 1979



[a]Includes territories and Indian lands.

Source: U.S. Environmental Protection Agency, "A Preliminary Analysis of Drinking Water Regulation Compliance," 1980.

monitoring programs and to recommend improvements. Eighteen agencies participated, and the task force work was completed in early 1980.[122]

The task force found more than 100 water monitoring programs managed by 20 federal agencies which spent approximately $275 million in fiscal year 1978. State and local governments are also extensively involved in water quality monitoring.

The task force identified two major problems—coordination and quality assurance. Program managers often do not know about or consider outside users in the design of monitoring systems; further, many monitoring programs have not been fully endorsed by agency management, are insufficiently funded, and do not provide specific guidance to field monitoring organizations.

Some of the task force recommendations are now being implemented. EPA, USGS, and CEQ are reviewing the design of national monitoring networks. EPA is also working to improve internal data quality assurance. In May 1979, the Administrator issued a "Quality Assurance Policy Statement" requiring all its offices and laboratories as well as all EPA-supported entities providing environmental data to participate in quality assurance programs.[123] This policy places direct responsibility on EPA managers to ensure that all environmental data used by EPA are scientifically valid, defensible, and of known precision and accuracy.

In July 1979, EPA established a Deputy Assistant Administrator Committee on Monitoring and Information Management to oversee all EPA monitoring programs and to recommend monitoring and information management policy for the Agency, including review and approval of all systems and redirection of resources where necessary. As of July 1980, the Committee had reviewed EPA's ambient monitoring programs, had recommended a number of improvements, and had begun to study source monitoring.

POLICIES AND PROGRAMS

MUNICIPALITIES

Under the Federal Water Pollution Control Act Amendments of 1972, all municipal sewage treatment plants were to achieve secondary treatment (or more stringent treatment to meet then existing water quality standards) by 1977, with some extensions up to 1983, and they were all to use the "best practicable" waste treatment technology by 1983.[124] Since the Act was passed, some progress has been made, although a majority of cities still fail to meet the 1977 requirements.

Construction Grants

To help municipalities meet the sewage treatment goals, the Congress has appropriated $31.58 billion since 1972. The EPA

Construction Grants Program—also called the "201" Program—operating at roughly $3.5 billion per year, is by far the Agency's largest in terms of direct outlay.

By the end of 1979, EPA had obligated $24.4 billion of the Construction Grants appropriations, leaving about $7 billion unobligated. Since 1972, EPA has funded about 18,200 planning, design, or construction "projects," of which about 6,800 have been completed. Most of the "completed" projects, however, are completed designs. By December 1979, construction had begun on 5,623 projects, of which only 1,552 were in operation.[125]

Operation and Maintenance Problems

Existence of a municipal waste water treatment plant does not guarantee cleaner water. EPA has become increasingly aware of operation and maintenance (O&M) problems with existing plants. All too often, a particular plant does not or cannot operate according to design specifications for lack of skilled operators, chemical supplies, replacement parts, or periodic inspections.

EPA's annual inspection surveys for 1976 and 1977 found that only 50–55 percent of the plants examined were operating at or near design specification for removal of biochemical oxygen demand. Large plants were generally more fully staffed, funded, and repaired than small ones. The general level of waste water treatment plant performance remains substantially unchanged from previous years; less than one-half the plants perform satisfactorily. Compliance with secondary treatment standards showed marginal improvement, from 42 percent in 1974 to 45 percent for both 1976 and 1977.[126]

In a recent 42-month study of 103 facilities, EPA's Office of Research and Development concluded that significant potential exists for improving performance simply and inexpensively by upgrading O&M, upgrading management and administration, and making low-cost corrections of design deficiencies.[127]

EPA is working to increase federal, state, local, and private efforts to improve plant performance. First, EPA will give more attention to O&M in the evaluation of Construction Grants Program plans and of all new and upgraded plants conducted onsite within 1 year of startup. Second, EPA will increase attention to enforcement of municipal permits in order to ensure that recalcitrant communities fully meet their operation and maintenance responsibilities. Third, EPA hopes to strengthen the private sector's provision of technical assistance and training.

When sewage treatment plants chronically or critically malfunction, EPA, under provisions of the Clean Water Act of 1977, may take a city to court to force compliance by direct order or fine.[128] But it is difficult to force a city to pay a fine to the federal treasury, and without an effective and credible sanction, EPA is in a poor bargaining position with errant municipalities.

EPA believes that contracting with private companies may be useful in some situations. Some cities have hired private firms for garbage collection, often with improved service at lower costs. By extension, if a city's sewage plants do not meet EPA standards, a court could order the municipality to contract with a private company for assistance. There is no conclusive evidence that contractors are the answer to noncompliance, but there seems to be a growing demand for contract services in states with strict enforcement.

Recreation Potential

A new sewage treatment plant can enhance nearby recreational opportunities, both by improving water quality and through creative land use planning. Recognizing this potential, the Congress has directed that EPA "shall not make grants . . . for . . . treatment works unless the grant applicant . . . has analyzed the potential recreation and open space opportunities in planning the proposed . . . works."[129]

Several cities have combined sewage treatment facilities with another use. A Barrington, Rhode Island, pumping station was located next to an outdoor hockey rink and was designed to form bleachers for the spectators at little extra cost. In New York City, the 25th Ward Plant arranged to share its sludge loading pier with fishermen. In Morris County, New Jersey, a 13-mile footpath and greenway were constructed along a regional interceptor. In Hyattsville, Maryland, 10 miles of bike trails were built along a sewer line. In Monticello, Arkansas, an old waste water treatment facility was converted to a city park containing a swimming pool and adventure playground. Joint development plans involving adjacent land can be adapted to the 208 Water Quality Management planning process and the Clean Lakes Program, thus providing even larger areas for recreation.[130]

In 1979 EPA extended a cooperative program with what is now called the Heritage Conservation Recreation Service in the Department of the Interior to ensure consideration of public outdoor recreation in water pollution control projects. The two agencies have been concerned that state and local recipients of EPA construction grants develop new water-related recreation facilities. Communities can realize substantial savings and benefits by, for example, planning and acquiring shore frontage before the water cleanup causes land prices to escalate.

Innovative and Alternative Technologies

In the Clean Water Act of 1977, the Congress encouraged innovative and alternative (I/A) technologies for municipal waste water treatment by providing financial incentives for such projects through September 1981.[131]

EPA has defined alternative technologies as *proven* methods of waste water treatment that reclaim or reuse water, productively

recycle waste water constituents, or recover energy. Innovative processes and techniques are developed, but not fully proven, methods which offer an *advancement* in the method of achieving these goals. The Clean Water Act authorizes an increase from 75 to 85 percent in EPA's share of construction costs if a proposed municipal treatment plant incorporates approved I/A features.[132]

As of March 1980, EPA had made grants to 25 innovative and 188 alternative projects. Innovative projects received $3.8 million and alternative projects received $17.9 million.[133]

A problem with the program is that it may run out of funds before many projects have been completed. Given that the projects must employ new technologies, design can take 2 years or more. EPA has estimated that approximately 20 percent of fiscal year 1979 funds (and possibly a substantial portion of fiscal year 1980

Water hyacinths in the Ocala National Forest, Florida. Scientists are exploring its use in treating waste water (Elliott A. Norse).

funds) may not be obligated within the required 2 years. Further, most I/A projects in the planning and design stages will be ready for construction in fiscal year 1981, just as the program is scheduled to end.

Use of Sludge in Land Reclamation

The city of Philadelphia has successfully demonstrated an alternative technology in Somerset County—use of sewage sludge to revegetate disturbed land. In 1975, compelled by the Ocean Dumping Act of 1972,[134] which prohibits ocean dumping of sludge after December 31, 1981, Philadelphia developed a master plan for sludge disposal. The plan included strip mine reclamation which would gradually increase the use of sludge in revegetating despoiled land by back-hauling sludge to the sites in coal trucks. Having begun with a small-scale demonstration of revegetating mined land with digested sludge, the city is now reclaiming several large spoil sites in western Pennsylvania.

Because of initial opposition in mining communities, city engineers and consultants decided in 1977 to begin with a pilot project that would prove its environmental soundness. A public education program included public meetings, preparation of brochures, press releases, and a slide show.

On June 3, 1978, the state issued a solid waste permit to Philadelphia for the application of sludge to a 10-acre barren site in Somerset County. Following the grading and liming of the site, nearly 900 tons of air-dried composted sludge were spread and disked into the soil. The area was then seeded with a grass mixture. Sludge, soil, and ground water were measured before, during, and after application of the sludge. A lush grass cover grew rapidly. A report on the initial demonstration project found no adverse effects on the environment.[135]

After other demonstrations succeeded, the city, in cooperation with the Pennsylvania Department of Environmental Resources, obtained permits to reclaim nearly 800 acres of barren, abandoned strip mine during the summer of 1979. From June 1978 through October 1979, more than 300 acres were reclaimed with the incorporation of 17,000 tons of sludge. In 1980, nearly 1,000 acres were reclaimed.

The need for both strip mine reclamation and sludge disposal in Pennsylvania is apparent—there are more than 250,000 acres of disturbed strip mined land in Pennsylvania alone. But the cost of transporting the sludge from concentrated urban areas may be an obstacle to initiating projects in other areas.

INDUSTRIES

The Effluent Guidelines Program

In the Federal Water Pollution Control Act Amendments of

1972, the Congress required EPA to set effluent guidelines limiting industrial discharges into the nation's waterways.[136] The guidelines were to be based on "best practicable technology" (BPT) and the more stringent "best available technology" (BAT) for controlling pollution from each industry.

The 1977 Clean Water Act constituted a midcourse correction for EPA's industrial waste pollution control program. It shifted the focus of control efforts away from the conventional to the toxic pollutants. The 1977 Act requires EPA to develop industry effluent limits based on BAT for control of the 65 classes of toxic priority pollutants. In a recent survey, EPA found that all primary industries regularly discharge one or more toxic priority pollutants, as shown in Table 3–11.

In developing effluent guidelines, EPA integrates extensive economic studies and engineering cost estimates. The studies consider the total cost of various control strategies and estimate their effects on prices, production, industry growth, and employment. In addition, EPA estimates the number of plant closures which may result from a particular requirement, community effects of the closures, and availability of capital for financing pollution control.

EPA has proposed BAT effluent limitations for control of toxic priority pollutants for nine primary industries—leather tanning and finishing, textile mills, timber products processing, gum and wood chemicals, rubber manufacturing, petroleum refining, paint formulating, ink formulating, and inorganic chemicals manufacturing[137]—including "pretreatment" standards for existing and new indirect sources (discussed below) as well as "standards of performance" for new direct sources.

For several of the primary industries, EPA has proposed an indicator strategy as a key part of the effluent guidelines regulating toxic pollutants by establishing numerical limits on other indicator pollutants—that is, EPA chose this strategy because extensive data do not exist on the effectiveness of control technologies for toxic discharges and because it is difficult and costly to detect and monitor toxic pollutants. In justifying this course of action, EPA stated:

> The data available . . . generally show that when these "indicator" pollutants are controlled, the concentrations of toxic pollutants are significantly lower . . . . While the relationships between "indicator" pollutants and toxic pollutants are not quantifiable on a one-to-one basis, control of an indicator will reasonably assure control of toxics with similar physical and chemical properties responsive to similar treatment mechanisms.[138]

Some critics urge EPA to minimize its reliance on indicators because it encourages control of nontoxic conventional indicator pollutants rather than toxic pollutants; others object because it creates de facto BAT control of conventional pollutants. They are

Table 3–11

Primary Industry Discharges of Toxic Priority Pollutants, 1979

Industry	Organic chemicals		Metals	
	Number of samples	Number of pollutants present	Number of samples	Number of pollutants present
Soaps and detergents	20	11	20	10
Adhesives and sealants	11	24	11	10
Leather tanning	81	38	72	10
Textile products	121	46	121	14
Gum and wood products	18	9	18	14
Pulp and paper	98	37	44	14
Timber	285	49	261	13
Printing and publishing	109	51	66	14
Paint and ink	94	42	149	13
Pesticides	147	80	104	14
Pharmaceuticals	95	49	77	12
Organics and plastics	723	106	557	14
Rubber	67	46	54	9
Coal mining	249	47	94	12
Ore mining	72	12	64	14
Paving and roofing	8	0	8	7
Steam electric power plants	84	29	82	9
Petroleum refining	76	58	346	12
Iron and steel	431	59	414	14
Foundries	54	46	54	14
Electroplating	18	17	18	9
Nonferrous metals	173	43	146	14
Batteries	3	8	0	NM
Coil coating	12	17	12	6
Photographic	25	42	0	NM
Inorganic chemicals	107	38	107	13
Electrical	35	36	2	14
Auto and other laundries	56	61	45	11
Phosphates	33	28	0	NM
Plastics processing	1	8	0	NM
Explosives	16	2	16	8
Porcelain and enameling	19	11	12	7
Landfill	7	17	NM	NM
Mechanical products	35	51	NM	NM

NM = No measurements taken.

Source: Robert B. Schaffer, U.S. Environmental Protection Agency, Effluent Guidelines Division.

concerned that, without specific toxic effluent limits, industry may have little incentive to develop and apply control technologies and process changes designed specifically to remove toxic pollutants.

The Pretreatment Program

Many industrial facilities release their liquid wastes to a publicly owned treatment work (POTW) rather than into a waterway. The Clean Water Act directs EPA to establish national standards for pretreatment of industrial waste waters that are not compatible with

municipal treatment plants.[139] An EPA study of major industries found only a few categories (but a large number of plants) which will not require pretreatment control, as shown in Table 3–12.

In June 1978, EPA proposed its General Pretreatment Regulations and a national pretreatment strategy.[140] They are designed to prevent chemical interferences with POTW operation, to prevent introduction of toxic pollutants that could pass through a POTW, and to prevent the contamination of sewage sludge to an extent that would limit either its beneficial uses on land or any other

Table 3–12

Industries Discharging into Municipal Sewage Treatment Plants, 1979

Industry	Number of plants discharging into publicly owned treatment works	Number of plants subject to pretreatment regulations
Soaps and detergents	450	400
Adhesives and sealants	500	500
Leather tanning	170	170
Textile products	1,700	915
Gum and wood products	7	6
Pulp and paper	260	50
Timber	189	49
Printing and publishing	63,000	2,300
Paint and ink	1,600	460
Pesticides	46	37
Pharmaceuticals	200	150
Organic chemicals	900	720
Plastics and synthetics	160	128
Rubber	537	9
Coal mining	0	0
Ore mining	0	0
Paving and roofing	138	0
Steam electric power plants	150	150
Petroleum refining	48	48
Iron and steel	238	237
Foundries	880	880
Electroplating	16,086	16,086
Nonferrous metals	79	57
Batteries	170	170
Coil coating	50	50
Photographic	110	110
Inorganic chemicals	120	108
Electrical	8,000	500
Auto and other laundries	90,000	1,500
Plastics processing	2,700	1,350
Explosives	0	0
Porcelain and enameling	138	138
Mechanical products	71,000	0
Carbon black	1	1
Aluminum forming	70	70
Copper products	57	57

Source: Jefferey Denit, U.S. Environmental Protection Agency, Office of Water Regulations and Standards.

environmentally sound disposal practice. Existing facilities have 3 years from the date of promulgation of final regulations to achieve pretreatment standards, but facilities opening after that date will have no grace period. Enforcement of the national pretreatment standards for toxic substances and establishment of local pretreatment standards will be the responsibility primarily of each publicly owned treatment facility that has an EPA or NPDES state-approved pretreatment program. EPA and the states with NPDES permitting authority have backup and oversight responsibility in ensuring that indirect dischargers install control technology and comply with pretreatment standards.

PERMITS, COMPLIANCE, AND ENFORCEMENT

NPDES Permits

Every public or private facility that discharges wastes directly into waters of the United States must have a permit under the Clean Water Act.[141] These National Pollutant Discharge Elimination System permits are issued by an EPA regional office or by a state with an EPA-approved program. In February 1980, EPA had approved programs in 33 states and territories.

An NPDES permit generally states discharge limitations for specific pollutants, establishes schedules for upgrading controls to meet such limits, and requires monitoring and periodic reports on compliance. Most compliance reports are based on samples taken and analyzed by persons working for or retained by the discharging facility.

As shown in Table 3–13, nearly 59,000 NPDES permits have

Table 3–13

NPDES Permits[a] Issued as of February 12, 1980

EPA region	Nonmunicipal	Municipal	Total
I	1,554	556	2,110
II	2,114	875	2,989
III	5,817	1,463	7,280
IV	10,264	2,463	12,727
V	11,307	4,140	15,447
VI	2,761	1,766	4,527
VII	4,273	2,045	6,318
VIII	1,997	1,049	3,046
IX	1,544	447	1,991
X	1,881	591	2,472
Total	43,512	15,395	58,907

[a] Does not include federal facilities.

Source: Rosanne Light, U.S. Environmental Protection Agency, Office of Enforcement.

been issued to municipal (mostly sewage treatment) and nonmunicipal (mostly industrial) dischargers.

EPA classifies dischargers as "major" and "minor" permit holders. At the beginning of 1980, EPA considered 3,688 municipal permit holders and 3,662 nonmunicipal permit holders major. In addition, 218 federal facilities were considered major. All other dischargers were minor. The Agency focuses most monitoring and enforcement activities on the majors, roughly one in eight of all dischargers. The majors are responsible for well over 50 percent, by volume, of all discharges.[142]

When NPDES permits were initially issued, the decision to classify permits as major or minor was left to the judgment of EPA regional offices, and the lack of guidelines led to inconsistencies in the definition of a major NPDES discharger. Because classification of a discharger was often based on size, small but potentially toxic dischargers were often classified as minor dischargers.

In order to standardize designation of major and minor dischargers, the Office of Water Enforcement developed, and is implementing, a system for reclassifying NPDES industrial permits. All primary and all major secondary dischargers will be ranked by toxicity potential, water quality impact, flow characteristics, drinking water source impact, and conventional pollutant load. This reclassification will ensure that a small but toxic discharger is considered a major discharger, particularly if it adversely affects the quality of a stream or has the potential to affect public health through contamination of drinking water supplies.

In February 1980, EPA estimated that 63 percent (2,317 of 3,688) of major municipal treatment facilities were not yet in compliance with the original July 1, 1977, statutory deadline requiring secondary treatment or more stringent treatment necessary to meet water quality standards.[143]

EPA can take several types of actions against a municipality or firm found violating the conditions of its NPDES permit. In fiscal year 1979, as shown in Table 3–14, EPA issued 149 Notices of Violation and 516 Administrative Orders and referred 71 cases to the Department of Justice, with a higher proportion in the nonmunicipal category. Referrals to Justice are frequently settled out of court. In 52 referral cases closed in fiscal year 1979, approximately $7.55 million in fines and penalties were levied.[144]

Consolidation of Permits

Commonly, a single industrial facility must comply with several EPA or state permit requirements for its different activities. In the past, different EPA or state agency staffs reviewed the various permit applications, creating the potential for duplication or contradiction.

To ensure consistency and to minimize administrative costs to both industry and the regulators, EPA established a Permits Consolidation Task Force to determine the extent to which permit

programs should be consolidated. Reporting in December 1978, the Task Force made specific recommendations.[145]

Table 3–14

EPA Enforcement Actions for Violation of NPDES Permits

Action	Fiscal year					
	1977		1978		1979	
	Non-municipal	Municipal	Non-municipal	Municipal	Non-municipal	Municipal
Notice of violation	184	113	121	82	64	85
Administrative order	495	633	489	241	347	169
Referral to Department of Justice	75	23	122	27	61	10

Source: Rosanne Light, U.S. Environmental Protection Agency, Office of Enforcement.

In addition, EPA has promulgated consolidated permit regulations covering five permit programs.[146] Wherever possible, these regulations standardize permit procedures and other basic program requirements. They are intended to facilitate joint processing of several EPA permits for a single project required by:

- The Hazardous Waste Management Program under the Resource Conservation and Recovery Act[147]
- The Underground Injection Control Program under the Safe Drinking Water Act[148]
- The National Pollutant Discharge Elimination System under the Clean Water Act.[149]

The regulations also establish the state requirements for the Section 404 Dredge or Fill Program under the Clean Water Act[150] and a permit decisionmaking procedure for EPA permits issued under the Prevention of Significant Deterioration Program under the Clean Air Act.[151]

Efforts are now underway to establish a single permit-writing unit in each regional office, with regional coordinators to expedite the processing of permits.

Many of the same problems of duplication and conflict exist at the state level. Although EPA must approve state programs under the Clean Water Act, the Resources Conservation and Recovery Act, and the Safe Drinking Water Act, it does not require that states consolidate their permit programs. EPA has encouraged the states to adopt 'one-stop" permit processing and hopes that its permit consolidation initiative will be a model for state efforts.

NONPOINT SOURCES OF POLLUTION

The distinction between point and nonpoint sources of water pollution is not always clear. Point sources generally discharge into surface waters through a discrete pipe, outfall, or ditch, and nonpoint sources generally discharge in a more diffuse way, for example, land runoff.

Nonpoint source water pollution is among the most challenging of pollution problems. In contrast to the important progress made during the 70s in controlling industrial point source discharges and in upgrading municipal sewage treatment facilities, progress with nonpoint sources is negligible.

Pollution from Unregulated Sources

The General Accounting Office (GAO) estimated that less than one-half the pollutants entering the nation's waters are from regulated point sources and municipal treatment plants.[152] If the nation is to achieve clean water goals, currently uncontrolled nonpoint sources must be controlled.

The most important nonpoint sources of pollution are agricultural activities, urban storm water runoff, silviculture, and individual waste water disposal systems. As described in the 1979 Annual Report, nearly all drainage basins are affected by pollution from agricultural and urban runoff.[153]

Agriculture Erosion of topsoil has reached 4.8 billion tons per year.[154] Water-induced soil losses total 3.8 billion tons, and an additional 1 billion is stripped from farms by wind.[155] These losses seriously affect not just productive capacity but also the quality of the waters into which much of this soil flows. Scientists estimate that approximately one-half of the sediment entering streams, rivers, and lakes stems from soil erosion on cropland.[156] According to the GAO, soil losses caused by poor agricultural practices are 25 percent worse today than in 1934.[157] The GAO reports that soil losses on cropped land are particularly alarming in Illinois, Iowa, Kansas, New Mexico, North Dakota, Texas, Washington, and Wisconsin.[158] In Illinois, at least 181 million tons of soil wash from cropland in an average year—about 2 bushels of soil for each bushel of corn produced in the state.[159] According to the Illinois Natural History Survey, the backwater lakes along the Illinois River are half filled with mud because of siltation from neighboring farms, most of it in the last 15 years.[160]

Agricultural runoff contains nutrients from fertilizers and the soil; they can drastically upset natural ecological balances. In 1979, farmers used about 51 million tons of commercial fertilizers,[161] containing roughly 21 percent nitrogen, 11 percent phosphorus, and 12 percent potassium. As much as 7.5 million tons of nitrogen and 600,000 tons of phosphorus from all agricultural sources run off into surface waters each year.[162]

Construction Water pollution from construction sites can be severe. In Gaithersburg, Maryland, for example, the gross erosion rate was 188 tons per acre per year, of which 73 tons were delivered to receiving waters.[163] No national totals are known.

Silviculture Unless carefully planned and conducted, forestry activities can be extremely destructive of streams and rivers. On steep slopes, poor road construction can result in massive soil shifts and landslides that can ruin adjacent water courses. One example is an undisturbed area in an Oregon forest which experienced 0.05 landslides per 1,000 acres. When logging roads were built, the number of landslides increased to 125.9 per thousand acres.[164]

Poorly designed culverts at road crossings can seriously impair water quality. In a northern California watershed, streams carried 250 times more sediment after a short segment of road was built than they did in a nearby undisturbed watershed.[165] Following road construction in an Oregon watershed, the maximum suspended sediment concentration increased to more than 6,000 parts per million, compared to 330 ppm before construction.[166] If riparian areas are completely logged, roots that bind the soil can be destroyed, causing the soil strata to slump into streams.

Removal of shade cover as a result of a clearcutting can raise water temperatures significantly, compounding nutrient pollution problems and creating serious problems for fisheries. Such logging raised the temperature of one Oregon stream from a prelogging level of 61° F to 85° F.[167]

Urban Runoff A primary cause of degraded water quality in populated areas is urban runoff. It affects more than one-half the nation's river basins.[168] Urban runoff contains almost every type of pollutant; the most damaging are suspended solids and toxic substances, particularly heavy metals, but it also contains bacteria, oxygen-demanding materials, nutrients, asbestos, oil and grease, and other pollutants. A study of Washington, D.C., found that in water from city streets the concentration of suspended solids was 104 times higher than effluent from a secondary sewage treatment plant. The lead concentration was 1,015 times higher.[169]

Mining Approximately 2.7 million acres of formerly mined lands need reclamation—1.1 million acres from coal mining, 800,000 acres from sand and gravel mining, and 800,000 acres from other mining. Acid runoff from coal mines causes severe water quality problems. Pennsylvania, Ohio, Illinois, Kentucky, West Virginia, Alabama, and Missouri each have more than 50,000 acres of unreclaimed coal mine land.[170]

Livestock Livestock produced about 1.2 billion tons of wastes annually. Fifty percent is produced by unconfined animal operations, which use about 40 percent of the entire land area in the country.[171]

Septic Systems Malfunctioning septic systems cause water quality problems in 43 percent of the nation's river basins.[172] Septic sys-

tems serve 19.5 million dwellings[173] and an estimated 50 million people.

Salinity About 58 million acres—14 percent—of cropland are irrigated, most of them in the western states. Salinity is a significant problem in about 20 percent of the irrigated lands of the West, where erosion contributes 90–100 million tons of salt to water courses, degrading supplies.[174]

Remedies There are various techniques for decreasing pollution from currently unregulated nonpoint sources. Known as Best Management Practices (BMPs), they are just that—practices such as soil tilling that minimizes soil erosion in rural areas and street sweeping that minimizes total suspended solids in urban runoff.

For the nation to have clean waters, it must become a high national priority to ensure that BMPs are properly installed, maintained, and operated. Strong regulatory measures must be applied nationwide to ensure that Best Management Practices are implemented successfully to achieve water quality goals.

EPA's Water Quality Management Program

The Clean Water Act gives EPA no specific authority to regulate pollution from nonpoint sources. EPA is attempting to address nonpoint source pollution problems primarily through the Water Quality Management Program, created by Section 208 of the Act. Regional planning agencies or the states must prepare "208" or "WQM" plans to identify and propose solutions to water quality problems. The plans must include both point and nonpoint sources in surface and ground waters. However, the plans are not binding. EPA expects to complete the current 208 areawide planning grant program in fiscal year 1983.

EPA grants under Section 106 of the Clean Water Act assist state and interstate agencies in the prevention, reduction, and elimination of water pollution, including that from nonpoint sources. Funding has declined in the last several years, and costs have increased. EPA and state representatives will recommend revisions of Section 106 management policies and allocation formulae by fiscal year 1982.

In carrying out its responsibilities under Section 208 of the Clean Water Act, EPA has focused on two nonpoint sources—urban storm runoff and agricultural runoff.

Although many 208 plans recognize urban runoff as an important water quality problem, controls are hard to implement. EPA's Nationwide Urban Runoff Program will gather data on urban runoff and will test control methods. Since 1978, EPA, the states, and regional agencies have selected 30 differing areas to develop BMPs.[175]

EPA and the Department of Agriculture (USDA) are cooperating in selecting, funding, and managing projects to improve control of agricultural runoff. A Model Implementation Program has begun in seven agricultural areas to test BMPs, to determine farmers' attitudes, and to document costs. The projects were planned for a 3-year

period ending September 1980 but may be extended on an individual basis.[176]

Another EPA–USDA demonstration program for the control of rural nonpoint source pollution is the Rural Clean Water Program. Administered by the Agricultural Stabilization and Conservation Service of USDA, projects are of 3–10 years' duration. Approximately one dozen projects will be initiated during fiscal year 1980.[177]

LAKES

EPA's Clean Lakes Program

National efforts to protect and improve lakes are increasingly significant today. As travel becomes more costly, lakes—and rivers—near major population centers will provide even more important recreational opportunities.

Over 99 percent of the population lives within 50 miles of a publicly owned fresh water lake. At least one-third of the population lives within 5 miles of a lake. A conservative estimate is that more than 10,000 of some 37,000 publicly owned lakes are in need of pollution reduction or restoration.[178]

The quality of a lake's water is determined primarily by natural processes and human activities in its watershed. Watersheds of publicly owned lakes cover 42 percent of the land.[179] The amount of sediment entering lakes from this large area is significant, and the cost of removing the sediment is large. Nearly 70 percent of the 92 restoration projects supported by the EPA Lakes Program involve sediment removal.[180]

EPA first established the Clean Lakes Program in 1975 to fund state and local demonstration projects to restore publicly owned fresh water lakes. The need for and the success of the Program prompted EPA to shift to a full-scale operational program. In 1979, EPA made the Program an integral part of state water quality planning and management efforts through the state-EPA agreement process.

Thirty states are conducting or will initiate lake classification surveys in fiscal year 1980 to rank problem lakes. EPA's new regulations require the states to complete the surveys by January 1, 1982, in order to remain eligible for financial support.[181] States can receive 70 percent federal assistance to study high priority problem lakes and to design corrections for particular problems. Twenty-nine states have 72 diagnoses underway; 10 awards were part of the President's Urban Initiative in November 1979.[182] Most of the lakes selected for study are associated with urban parks and are adversely affected by urban runoff.

Many lakes have large agricultural watersheds. In rural areas EPA and USDA work closely. Currently they share five Clean Lakes projects. The Cobbessee watershed, near Winthrop, Maine, is an outstanding example of this cooperative effort. The Clean Lakes Program helped finance animal waste storage facilities in the watershed,

where most of the 39 farmers have built or are building manure storage facilities. In addition, Annabessacook Lake, which suffered from excessive phosphorus enrichment and dense algal blooms, was treated with 100,000 gallons of aluminum sulfate and sodium aluminate to precipitate the phosphorus. Visibility in the lake has improved markedly—from 77 days with visibility of less than 2 meters (6.5 feet) in 1977 (before treatment) to 0 days with visibility of less than 2 meters in 1979 (after treatment and management of animal wastes).[183]

As of the end of July 1980, EPA had awarded $57.3 million in 45 states for the Clean Lakes Program—an 80 percent increase over the past year. These grants support 36 lake classification surveys, 72 diagnostic studies, and 92 restoration projects.

The 1980 Program evaluation notes that lake restoration procedures return public benefits at a rate of 8.3 to 1 for each federal dollar invested. Specifically, 28 Clean Lakes projects have returned $127 million in benefits, including recreation opportunities, flood control, local economic development, preservation of fish and wildlife, and increased agricultural productivity, for the $15 million invested.[184]

The Seven Lakes Study

In recent environmental impact statements (EISs) on seven rural lakes, EPA's Chicago office decided to look at water quality problems in small lakes in terms of more efficacious and less costly alternatives to the centralized sewers and treatment originally proposed. The statements show how application of the National Environmental Policy Act EIS review can cut costs, reduce harmful impacts, and improve planning.

The Chicago office has hundreds of grant applications pending on rural lake projects. Most of the lakes have substantial shore development and numerous seasonal residents. By 1977 it was clear that the proposals usually involved construction of a sewer around an entire lake, with the collected waste water treated at a central treatment plant. The projects would generally cause significant land use and population dislocations and would entail high costs.

In mid-1977, the Chicago office selected seven representative projects for individual EIS analysis. All involved uncertain impacts on lake water quality, high local costs, and other potential problems, including destruction of wetlands and/or endangered species habitat.

Innovative/alternative waste water treatment methods were considered—repair and upgrading of existing septic tanks and filter fields, water conservation, use of cluster systems (multifamily filter fields located on areas of good soil), mound systems, and separation of grey water (tub and laundry water) from black water (toilet wastes).

The first step was to determine the sources of the water quality problems, including an assessment of the condition of and limitations of septic tanks and other onsite sewage disposal treatment systems.

Advanced sensing methods showed that onsite sewage disposal systems were not the cause of all the water quality problems. On one lake, heavy nonpoint runoff produced a large effluent plume several times the strength of all onsite system plumes combined.[185] In another, massive ground water flows (10–12 feet per day) caused unusual problems with nutrients.[186] And in a chain of developed lakes, acid leaching from a bog released phosphorus in marl deposits into the lakes.[187] None of these conditions would have been detected by conventional means.

New detection techniques allowed planners to identify innovative and economical alternatives. Onsite sewage disposal systems causing water quality problems were identified and models of sources of problems were proposed. The studies suggested that on many lakes upgrading onsite treatment would have the same effect on overall water quality as the proposed sewer project.

Overall, modular use of decentralized treatment reduced project costs an average 60 percent, based on a lifetime cost over 20 years. Because of higher levels of grant eligibility, local user charges were cut 75–90 percent. Adverse impacts on wetlands were greatly reduced or were eliminated. The potential for encouraging population growth through sewer construction declined.

REFERENCES

1. U.S. Water Resources Council, *The Nation's Water Resources, 1975–2000*, Vol. 1: *Summary* (Washington, D.C.: U.S. Government Printing Office, 1978), p. 13.
2. U.S. Environmental Protection Agency, Office of Drinking Water, *Planning Workshops to Develop Recommendations for a Ground Water Protection Strategy: Appendices* (Washington, D.C.: U.S. Government Printing Office, 1980), p. II–5.
3. Commonwealth of Massachusetts, Special Legislative Commission on Water Supply, "Chemical Contamination: Working Paper for the Water Quality Task Force" (Boston, 1979), pp. 5, 21, 23, 27.
4. Information provided by Louis Schinazi, Regional Water Control Board, Los Angeles, September 1980.
5. Ronald B. Taylor, "TCE in Water: How Much Cancer Risk? Chemical Contamination of Wells Emerging as Major Problem," *Los Angeles Times*, September 24, 1979, p. 41.
6. Walter L.T. Hang and Joseph P. Salvo, *Toxics on Tap: Chemical Contamination of Long Island Drinking Water Supplies* (New York: Public Interest Research Group, Inc., 1980), p. II–34.
7. Letter from Francis T. Brezenski, Laboratory Director, U.S. Environmental Protection Agency, Region II, to William Althoff, Department of Special Services, New Jersey Department of Environmental Protection, May 12, 1976.
8. Robert H. Harris, Staff Scientist, Environmental Defense Fund, memorandum and attachments to Ruffin Harris, October 12, 1979.
9. R. Allen Freeze and John A. Cherry, *Groundwater* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1979), p. 2.
10. Swep T. Davis, Associate Assistant Administrator for Water and Waste Management, U.S. Environmental Protection Agency, testimony before the Joint Hearing of the Subcommittee on Health and the Environment

and the Subcommittee on Transportation and Commerce, House of Representatives, August 22, 1980, p. 2.

11. U.S. Water Resources Council, *supra* note 1, at 20.
12. James T.B. Tripp and Adam B. Jaffe, "Preventing Groundwater Pollution: Toward a Coordinated Strategy to Protect Critical Recharge Zones," *Harvard Environmental Law Review* 3:3 (1979).
13. *Id.* pp. 12–13.
14. Calculation adapted from U.S. Environmental Protection Agency, *supra* note 2, at Table I, p. II–3; James T.B. Tripp and Adam B. Jaffe, *supra* note 12, at 3.
15. U.S. Water Resources Council, *supra* note 1, at 18.
16. Based on U.S. Environmental Protection Agency, *supra* note 2, at Table 1, p. II–3.
17. *Ibid.*
18. Based on C. Richard Murray and E. Bodette Reeves, *Estimated Use of Water in the United States in 1975* (Arlington, Va.: U.S. Geological Survey, 1977), p. 20.
19. National Academy of Sciences, Safe Drinking Water Committee, *Drinking Water and Health* (Washington, D.C., 1977), p. 22; Clifford S. Russell, ed., *Safe Drinking Water: Current and Future Problems* (Washington, D.C.: Resources for the Future, 1978), p. 117.
20. Richard J. Lewis, ed., *Registry of Toxic Effects of Chemical Substances: 1978 Edition* (Washington, D.C.: U.S. Government Printing Office, 1979), p. 565 (KX4550000).
21. *Id.* p. 328 (FG4900000).
22. *Id.* p. 564 (KX3850000).
23. *Id.* p. 529 (KI0525000).
24. *Id.* p. 561 (KU9625000).
25. National Academy of Sciences, *supra* note 19, at 27, 28.
26. Clifford S. Russell, *supra* note 19, at 168; Nancy K. Kim and Daniel W. Stone, *Organic Chemicals and Drinking Water* (Albany: New York Department of Health, 1980), p. 20.
27. Safe Drinking Water Act, 42 U.S.C. § 300(f).
28. 40 Fed. Reg. 59570 (1975).
29. 43 Fed. Reg. 5756–80 (1978).
30. Information provided by William L. Lappenbusch, Chief, Health Effects Branch, Criteria and Standards Division, Office of Drinking Water, U.S. Environmental Protection Agency.
31. U.S. Environmental Protection Agency, Office of Drinking Water, "SNARL for Trichloroethylene" (Washington, D.C., November 1979), p. 1.
32. *Clean Water Report*, July 15, 1980, p. 145.
33. U.S. Environmental Protection Agency, *The Report to Congress: Waste Disposal Practices and Their Effects on Ground Water: Executive Summary* (Washington, D.C., 1977), p. 9.
34. Swep T. Davis, *supra* note 10, at 8.
35. Douglas M. Costle, "Enforcement and the EPA," *EPA Journal* 6(6):3 (1980); Barbara Blum, "Hazardous Waste Action," *EPA Journal* 6(6):7 (1980).
36. U.S. Environmental Protection Agency, *supra* note 33, at 19, 31.
37. Fred C. Hart Associates, "Analysis of the Technology, Prevalence, and Economics of Landfill Disposal of Solid Waste in the U.S.," Vol. II, prepared for the U.S. Environmental Protection Agency (Washington, D.C., 1979), p. 48.
38. Fred C. Hart Associates, "Preliminary Assessment of Cleanup Costs for National Hazardous Waste Problems," prepared for the U.S. Environmental Protection Agency (Washington, D.C., 1979), p. 22.
39. Lyle R. Silka and Francoise M. Brasier, "The National Assessment of the Ground Water Contamination Potential of Waste Impoundments"

(Washington, D.C.: U.S. Environmental Protection Agency, 1980), p. 4.

40. *Id.* p. 5.
41. U.S. Congress, House, Committee on Government Operations, *Interim Report on Ground Water Contamination: Environmental Protection Agency Oversight* (Washington, D.C.: U.S. Government Printing Office, 1980, errata sheet).
42. Geraghty and Miller, Inc., *The Prevalence of Subsurface Migration of Hazardous Chemical Substances at Selected Industrial Waste Land Disposal Sites* (Washington, D.C.: U.S. Environmental Protection Agency, 1979), p. v.
43. *Id.* pp. vii, viii.
44. Richard W. Eldridge, "1977 Update for Land Disposal Practices Survey," *Waste Age,* January 1978, p. 35.
45. Resource Conservation and Recovery Act of 1976, 42 U.S.C. §§ 6901–6987.
46. U.S. Environmental Protection Agency, *supra* note 33, at 22.
47. U.S. Environmental Protection Agency, *supra* note 2, at V–3.
48. U.S. Environmental Protection Agency, *supra* note 33, at 22.
49. Information supplied by W.L.T. Hang, Staff Scientist, New York Public Interest Research Group.
50. Lyle R. Silka and Francoise M. Brasier, *supra* note 39, at 4.
51. G.C. Slawson, Jr., ed., *Groundwater Quality Monitoring of Western Oil Shale Development,* EPA–600/7–79–023 (Springfield, Va.: National Technical Information Service, 1979), p. 1.
52. U.S. Environmental Protection Agency, *supra* note 33, at 308.
53. *Id.* p. 314.
54. Lyle R. Silka and Francoise M. Brasier, *supra* note 39, at 4. These figures differ slightly from figures in a previous draft report released the previous year (U.S. Environmental Protection Agency, *Surface Impoundments and Their Effects on Ground-Water Quality in the United States—A Preliminary Survey* (Washington, D.C.: U.S. Government Printing Office, 1978), p. 40).
55. Clifford S. Russell, *supra* note 19, at 62.
56. National Academy of Sciences, *supra* note 19, at 777–79; Richard J. Lewis, *supra* note 20, at 565 (KX4550000).
57. Information provided by the U.S. Environmental Protection Agency.
58. Nancy K. Kim, *supra* note 26, at 6.
59. *Id.* p. 10.
60. *Id.* Appendix D, p. 88.
61. Commonwealth of Massachusetts, *supra* note 3, at 11, 12.
62. U.S. Environmental Protection Agency, Oil and Special Materials Control Division, "Damages and Threats Caused by Hazardous Material Sites," WH–548 (Washington, D.C., draft, February 1980), p. 2.
63. Federal Water Pollution Control Act Amendments of 1972, as amended by the Clean Water Act of 1977, 33 U.S.C. §§ 1251–1376.
64. Safe Drinking Water Act, 42 U.S.C. §§ 300f to 300j–9.
65. Resource Conservation and Recovery Act of 1976, 42 U.S.C. §§ 6901–6987. The RCRA completely replaced the language of the Solid Waste Disposal Act of 1965, 42 U.S.C. §§ 3251–3259.
66. Toxic Substances Control Act of 1976, 15 U.S.C. §§ 2601–2629.
67. Surface Mining and Control and Reclamation Act of 1977, 30 U.S.C. §§ 1201–1328.
68. 33 U.S.C. §§ 1251–1376.
69. 33 U.S.C. § 1251(a).
70. 33 U.S.C. § 1252(a).
71. James T.B. Tripp and Adam B. Jaffe, *supra* note 12, at 11.
72. *Kentucky ex rel. Hancock* v. *Train,* 9 ERC 1280, 1282 (E.D. Ky., 1976).

73. James T.B. Tripp and Adam B. Jaffe, *supra* note 12, at 12.
74. Information provided by Marian Mlay, Associate Deputy Assistant Administrator, Office of Drinking Water, U.S. Environmental Protection Agency.
75. 33 U.S.C. § 1321.
76. Safe Drinking Water Act, 42 U.S.C. §§ 300f to 300j–10.
77. 42 U.S.C. § 300h–1.
78. 42 U.S.C. § 300h–3e.
79. 42 U.S.C. § 300h–1; 43 Fed. Reg. 43420 (1978).
80. 45 Fed. Reg. 42472 (1980).
81. James T.B. Tripp and Adam B. Jaffe, *supra* note 12, at 15.
82. 45 Fed. Reg. 42502 (1980).
83. 42 U.S.C. § 300h–3e.
84. Marian Mlay, *supra* note 74.
85. Resource Conservation and Recovery Act of 1976, 42 U.S.C. §§ 6901–6987. See reference 65.
86. Toxic Substances Control Act of 1976, 15 U.S.C. §§ 2601–2629.
87. Surface Mining Control and Reclamation Act of 1977, 30 U.S.C. §§ 1201–1328.
88. James T.B. Tripp and Adam B. Jaffe, *supra* note 12, at 26, 27.
89. New York State Department of Environmental Conservation, "Ground Water Classifications Quality Standards and Effluent Standards and/or Limitations."
90. U.S. Environmental Protection Agency, Office of Water Program Operations, *Clean Water Fact Sheet*, January 1980, p. 2.
91. U.S. Environmental Protection Agency, "Report on EPA Ambient Monitoring Activities—Water Quality Portion," draft (Washington, D.C., 1980), p. 6.
92. U.S. Environmental Protection Agency, Office of Water Planning and Standards, "A Water Quality Success Story—The Pemigewasset River, New Hampshire," October 1979.
93. U.S. Environmental Protection Agency, Office of Water Planning and Standards, "A Water Quality Success Story—The Hackensack River and Its Meadowlands," January 1978.
94. U.S. Environmental Protection Agency, Office of Water Planning and Standards, "A Water Quality Success Story—The Neches River Tidal Area," September 1978.
95. Tennessee Department of Public Health, Division of Water Quality Control, "Status of Water Quality in Tennessee, 1980 305(b) Report" (Nashville, 1980), p. 15.
96. U.S. Library of Congress, Congressional Research Service, *Resource Losses from Surface Water, Groundwater, and Atmospheric Contamination: A Catalog*, prepared for the Senate Committee on Environment and Public Works, 96th Cong., 2d Sess., Serial No. 96–9 (Washington, D.C. U.S. Government Printing Office, 1980), p. x.
97. California Water Resources Control Board, *Water Quality Inventory for Water Years 1978 and 1979* (Sacramento, 1980), pp. 23–25.
98. Arkansas Department of Pollution Control and Ecology, *Arkansas Water Quality Inventory Report, 1977* (Little Rock, 1977), p. 66.
99. U.S. Environmental Protection Agency, *supra* note 91, at 8.
100. Information provided by Thomas M. Murray, Office of Water Regulations and Standards, U.S. Environmental Protection Agency.
101. Information provided by Roy N. Puckett, Office of the Secretary of Commerce and Resources, Commonwealth of Virginia.
102. L. Hetting, E. Horn, and J. Tofflemire, *Summary of Hudson River PCB Study Results* (Albany: New York State Department of Environmental Conservation, 1978), pp. 79–84; U.S. Library of Congress, *supra* note 96, at 52.
103. Susan West, "Acid from Heaven," *Science News* 117:76 (1980).

104. Great Lakes Water Quality Board, *Great Lakes Water Quality: Seventh Annual Report [1978] to the International Joint Commission* (Windsor, Ontario: International Joint Commission, 1979), p. 5.
105. Great Lakes Water Quality Agreement of 1978, with annexes and terms of reference, between the United States and Canada, Ottawa, Ontario, November 22, 1978.
106. J.R. Vallentyne and N.A. Thomas, *Fifth Year Review of Canada-United States Great Lakes Water Quality Agreement, Report of Task Group III, A Technical Group To Review Phosphorus Loadings* (Windsor, Ontario: International Joint Commission, 1978), pp. 61–77.
107. Great Lakes Water Quality Board, Surveillance Subcommittee, *Great Lakes Water Quality, Seventh Annual Report, Appendix B* (Windsor, Ontario: International Joint Commission, 1979), p. 16; Great Lakes Water Quality Board, Surveillance Subcommittee, *Great Lakes Water Quality, Sixth Annual Report* (Windsor, Ontario: International Joint Commission, 1978), pp. 98, 99.
108. Great Lakes Water Quality Board, *Seventh Annual Report, Appendix B, supra* note 107, at 7.
109. *Id.* pp. 21, 22.
110. Great Lakes Water Quality Board, *supra* note 104, at 12, 13.
111. *Id.* p. 15.
112. Great Lakes Water Quality Agreement, *supra* note 105, at 18.
113. Great Lakes Water Quality Board, *Seventh Annual Report, Appendix B, supra* note 107, at 10, 14.
114. Great Lakes Water Quality Board, *supra* note 104, at 13.
115. *Id.* p. 7.
116. *Id.* p. 12.
117. U.S. Environmental Protection Agency, Office of Water and Hazardous Materials, *Quality Criteria for Water, July 1976* (Washington, D.C.: U.S. Government Printing Office, 1977), p. 54.
118. 42 U.S.C. §§ 300f to 300j–9.
119. 40 C.F.R. 141.
120. Information provided by David Schnare, Environmental Scientist, Office of Drinking Water, U.S. Environmental Protection Agency.
121. Council on Environmental Quality, *The President's Environmental Program—1977* (Washington, D.C.: U.S. Government Printing Office, 1977), pp. M–7, M–12.
122. Interagency Task Force on Environmental Data and Monitoring, *Final Report* (Springfield, Va.: National Technical Information Service, 1980).
123. Douglas M. Costle, Administrator, U.S. Environmental Protection Agency, memorandum, "Environmental Protection Agency (EPA) Quality Assurance Policy Statement," May 30, 1979.
124. Federal Water Pollution Control Act Amendments of 1972, 33 U.S.G. § 1311(b)2(B).
125. U.S. Environmental Protection Agency, *Clean Water Fact Sheet* (January 1980), pp. 1, 2.
126. Information provided by Lehn J. Potter, Chief, Municipal Operations Branch, Office of Water Program Operations, U.S. Environmental Protection Agency.
127. *Ibid.*
128. 33 U.S.C. § 1319.
129. 33 U.S.C. § 1281(g)(6).
130. Information provided by Irene L. Murphy, Chief, Water Resources Section, Heritage Conservation and Recreation Service, U.S. Department of the Interior.
131. 33 U.S.C. § 1281(d) *et seq.*
132. 33 U.S.C. § 1282(a)2.

133. Information provided by U.S. Environmental Protection Agency, Office of Water Program Operations.
134. Marine Protection, Research, and Sanctuaries Act of 1972, 33 U.S.C. § 1401 *et seq.*
135. William E. Sopper and Sonja N. Kerr, "Strip Mine Reclamation Demonstration Project—Somerset County," prepared for the Philadelphia Water Department, pp. 1, 41.
136. Federal Water Pollution Control Act Amendments of 1972, 33 U.S.C. § 1311(b)(1).
137. Leather tanning and finishing, 40 C.F.R. Part 425, 44 Fed. Reg. 38746 (1979); textile mills, 40 C.F.R. Part 410, 44 Fed. Reg. 62204 (1979), corrected 44 Fed. Reg. 69687 (1979), 45 Fed. Reg. 52185 (1980); timber product processing, 40 C.F.R. Part 429, 44 Fed. Reg. 62810 (1979); gum and wood chemicals, 40 C.F.R. Part 454, 44 Fed. Reg. 68710 (1979), corrected 45 Fed. Reg. 3604 (1980); rubber manufacturing, 40 C.F.R. Part 428, 44 Fed. Reg. 75016 (1979); petroleum refining, 40 C.F.R. Part 419, 44 Fed. Reg. 75926 (1979); paint formulating, 40 C.F.R. Part 446, 45 Fed. Reg. 912 (1980); ink formulating, 40 C.F.R. Part 447, 45 Fed. Reg. 928 (1980); inorganic chemicals manufacturing, 40 C.F.R. Part 415, 45 Fed. Reg. 49450 (1980), corrected 45 Fed. Reg. 58383 (1980).
138. 44 Fed. Reg. 38757 (1979).
139. Clean Water Act of 1977, 33 U.S.C. § 1314(g)(1).
140. William R. Diamond, Office of Water Enforcement, U.S. Enforcement Protection Agency, "National Pretreatment Program Overview," presented at the Industrial-Municipal Pretreatment Implementation Seminar, Chicago, March 20, 1980, p. 2.
141. Clean Water Act, 33 U.S.C. § 1342.
142. Information provided by Heather Struck, Counsel, Municipal Branch, Permits Division, U.S. Environmental Protection Agency.
143. Information provided by Rosanne Light, Acting Chief, Compliance Branch, Office of Water Enforcement, U.S. Environmental Protection Agency.
144. *Ibid.*
145. Heather Struck, *supra* note 142.
146. 45 Fed. Reg. 33517 (1980).
147. 42 U.S.C. § 6921.
148. 42 U.S.C. § 300h.
149. 33 U.S.C. § 1342.
150. 33 U.S.C. § 1344.
151. 42 U.S.C. § 7470.
152. U.S. Comptroller General, "National Water Quality Goals Cannot Be Attained without More Attention to Pollution from Diffused or Non-Point Sources," CED–78–6 (Washington, D.C., General Accounting Office, 1977), p. i.
153. Council on Environmental Quality, *Environmental Quality—1979: The Tenth Annual Report of the Council on Environmental Quality* (Washington, D.C.: U.S. Government Printing Office, 1979), p. 148.
154. U.S. Department of Agriculture, "Soil and Water Resources Conservation Act: 1980 Appraisal," Review Draft, Part I (Washington, D.C., 1979), Tables 2B–3 to 2B–10, pp. 2–30 to 2–41.
155. *Ibid.*
156. U.S. Department of Agriculture, "Soil and Water Resources Conservation Act: 1980 Appraisal," Review Draft, Part II (Washington, D.C. 1980), p. 3–81 and Table 3B–9, p. 3–82.
157. U.S. Comptroller General, "To Protect Tomorrow's Food Supply, Soil Conservation Needs *Priority* Attention," CED–77–30 (Washington, D.C., General Accounting Office, 1977), p. 6.
158. *Id.* p. 16.

159. "Illinois River Winding Its Way to a Slow Death," *St. Louis Post Dispatch*, February 15, 1979.
160. D.W. Steffeck et al., "Effects of Decreasing Water Depths on Sedimentation of Illinois River Bottom Land Lakes," *Water Resources Bulletin* 16:553–55 (1980); F.C. Bellrose et al., "Waterfowl Populations and the Changing Environment of the Illinois River Valley," *Illinois Natural History Survey Bulletin*, Vol. 32, Art. 1 (1979).
161. U.S. Department of Agriculture, Crop Reporting Board, "Commercial Fertilizer Consumption for Year Ended June 30, 1979," USDA–ESCS–SPCR–7 (Washington, D.C., 1979).
162. U.S. Department of Agriculture, *supra* note 156, at 3–81.
163. U.S. Environmental Protection Agency, Office of Water Planning and Standards, "The Urban Stormwater Presentation" (Washington, D.C., June 1979), p. 10.
164. Jack S. Rothacher and Thomas B. Glazebrook, "Flood Damage in the National Forests of Region 6" (Portland, Oreg.: Pacific Northwest Forest and Range Experiment Station, 1968).
165. R.L. Fredrikson, U.S. Department of Agriculture, "Erosion and Sedimentation Following Road Construction and Timber Harvest on Unstable Soils in Three Small Western Oregon Watersheds," U.S. Forest Service Research Paper PNW–10 (Portland, Oreg., 1970), p. 8.
166. R.L. Frederikson, "Impact of Forest Management on Stream Water Quality in Western Oregon," in *Pollution Abatement and Control in the Forest Products Industry, 1971–72 Proceedings of the 26th Annual Meeting of the Forest Product Research Society* (Madison, Wis.: Forest Product Research Society, 1972), pp. 37–50.
167. Richard W. Lantz, *Guidelines for Stream Protection in Logging Operations* (Portland: Oregon State Game Commission, 1971).
168. U.S. Environmental Protection Agency, *National Water Quality Inventory, 1977 Report to Congress*, EPA–440/4–78–001 (Washington, D.C.: U.S. Government Printing Office, 1978), p. 15.
169. U.S. Environmental Protection Agency, *supra* note 163.
170. U.S. Department of Agriculture, *supra* note 157, at 3–96.
171. *Id.* p. 3–81.
172. U.S. Environmental Protection Agency, *supra* note 168, at 15.
173. U.S. Comptroller General, "Community-Managed Septic Systems—A Viable Alternative to Sewage Treatment Plants," CED–78–168 (Washington, D.C.: U.S. General Accounting Office, 1978), p. 1.
174. U.S. Environmental Protection Agency, *supra* note 156, at 3–82 to 3–83.
175. U.S. Environmental Protection Agency, *Water Quality Management: Five-Year Strategy FY 81 Baseline* (Washington, D.C.: U.S. Government Printing Office, 1980), p. 14.
176. *Id.* p. 15.
177. *Ibid.*
178. JACA Corporation, "An Assessment of Economic Benefits of 28 Projects in the Section 314 Clean Lakes Program," prepared for the U.S. Environmental Protection Agency (Washington, D.C., 1980), pp. 1, 2.
179. *Ibid.*
180. Information provided by Robert Johnson, Acting Branch Chief, Clean Lakes, Aquatic Protection Branch, U.S. Environmental Protection Agency.
181. 45 Fed. Reg. 7788 (1980).
182. Robert Johnson, *supra* note 180.
183. JACA Corporation, *Lake Restoration in Cabbossee Watershed: Capsule Report*, prepared for the U.S. Environmental Protection Agency (Washington, D.C., 1980).
184. JACA Corporation, *supra* note 178, at 11.

185. U.S. Environmental Protection Agency, environmental impact statement, *Wastewater Treatment Systems for Rural Lake Projects, Case Study No. 2: Green Lake, Minnesota* (draft, June 1979), p. 57.
186. U.S. Environmental Protection Agency, environmental impact statement, *Alternative Wastewater Treatment Systems for Rural Lake Projects, Case Study No. 5: Otter Tail County Board of Commissioners* (draft, November 1979), p. 1.
187. U.S. Environmental Protection Agency, environmental impact statement, *Wastewater Treatment Systems for Rural Lake Projects: Case Study No. 4: Steuben Lakes Regional Waste District* (draft, November 1979), p. i.

Chapter 4

AIR QUALITY

Available data suggest that, overall, the nation's air quality is continuing to improve, although serious problems exist in many areas, including some of the most densely populated.

An examination of 23 urban areas for which 5 years' data have been compiled shows that in the aggregate, the number of days in violation of the National Ambient Air Quality Standards (NAAQS) —and thus classified as unhealthful—decreased 18 percent between 1974 and 1978. The nation as a whole shows similar improvement. Monitoring data from both urban and rural sites indicate that the national average annual concentrations of carbon monoxide, sulfur dioxide, and total suspended particulates dropped between 1973 and 1978, but ozone concentrations remained constant.

Ozone and carbon monoxide continue to be the pollutants most often in the unhealthful range. In most EPA regions, fewer than 5 percent of the reporting counties had 10 or more days in violation of the NAAQS for nitrogen oxides, surfur dioxide, or total suspended particulates in 1978. But for ozone and carbon monoxide, more than 25 percent of reporting counties in most EPA regions had 10 or more days in violation.

Severe air quality problems continue in several major urban areas. New York and Los Angeles had 174 and 206 days, respectively, in 1978 when air pollution readings violated national standards. Although air pollution levels are improving in these and many other cities, there are exceptions. Kansas City had 56 unhealthful days in 1978, 10 times the number in 1974, and Houston had 94 such days, almost 3 times the number in 1974.

In January 1979, the Environmental Protection Agency (EPA) relaxed the NAAQS for ozone from 0.08 parts per million to 0.12 ppm, and the conditions and trends presented in this chapter reflect the new ozone standard. EPA is continuing its review of the NAAQS, as mandated by the 1977 amendments to the Clean Air Act.[1] In August 1980, EPA proposed tightening the short-term standard for carbon monoxide in order to protect individuals with heart diseases.[2]

Two other problems, both of which may be aggravated by efforts to achieve energy self-sufficiency, are of increasing concern: acid rain

and the quality of air indoors. Acid rain is a growing problem in the northeast United States, Canada, and Scandinavia. It is believed to be created when sulfur oxide and nitrogen oxide emissions—for which one important source is coal-burning power plants—combine with water in the atmosphere. Acid precipitation may fall to earth many miles from where the pollutants were emitted. An interagency committee has been set up to coordinate federal research on the problem.[8]

The presence of air pollutants in homes, including nitrogen oxides and other toxic substances, is also receiving attention. As many people insulate their homes, they may also be reducing ventilation, and the buildup of pollutants emitted by such common items as gas stoves and furniture padding could become a problem.

CONDITIONS AND TRENDS

URBAN AIR QUALITY

In order to examine trends in urban air quality, CEQ selected 23 geographically diverse Standard Metropolitan Statistical Areas (SMSAs) for which reliable air quality data existed in the EPA National Aerometric Data Bank for the 5 years 1974–78 (1978 is the last year for which complete air quality data existed when this Annual Report was prepared). In addition, air quality data for the New York SMSA are presented for 1975–78 (the data for 1974 were inadequate). Figure 4–1 shows the number of days each year that were classified as unhealthful, very unhealthful, or hazardous for each of the 24 SMSAs. These classifications are based upon the Pollutant Standard Index (PSI), which is explained below.

As Figure 4–1 indicates, air quality trends in these 24 SMSAs are mixed. Some areas—Los Angeles, Louisville, and New York, for example—have shown steady progress or substantial recent improvements. Other areas like Houston, Chicago, and Kansas City show some signs of deteriorating air quality as of 1978. In other areas, air quality trends appear more uneven.

The data for these individual SMSAs can be aggregated for a more comprehensive view of air quality in 23 U.S. cities from 1974 to 1978 (New York is excluded because of the lack of adequate 1974 data). According to this aggregate measure, air quality seems to be improving. As Figure 4–2 shows, the total number of unhealthful, very unhealthful, and hazardous days in the 23 SMSAs declined substantially from 1,985 in 1974 to 1,637 in 1978, a reduction of about 18 percent. The number of very unhealthful and hazardous days in the 23-SMSA group fell from 547 in 1974 to 358 in 1978, a reduction of 35 percent, and the number of hazardous days fell from 33 in 1974 to 15 in 1978, a reduction of 55 percent. This overall improvement has been quite steady, with the total number of

Figure 4-1

Trends in PSI Levels in 23 SMSAs, 1974-78

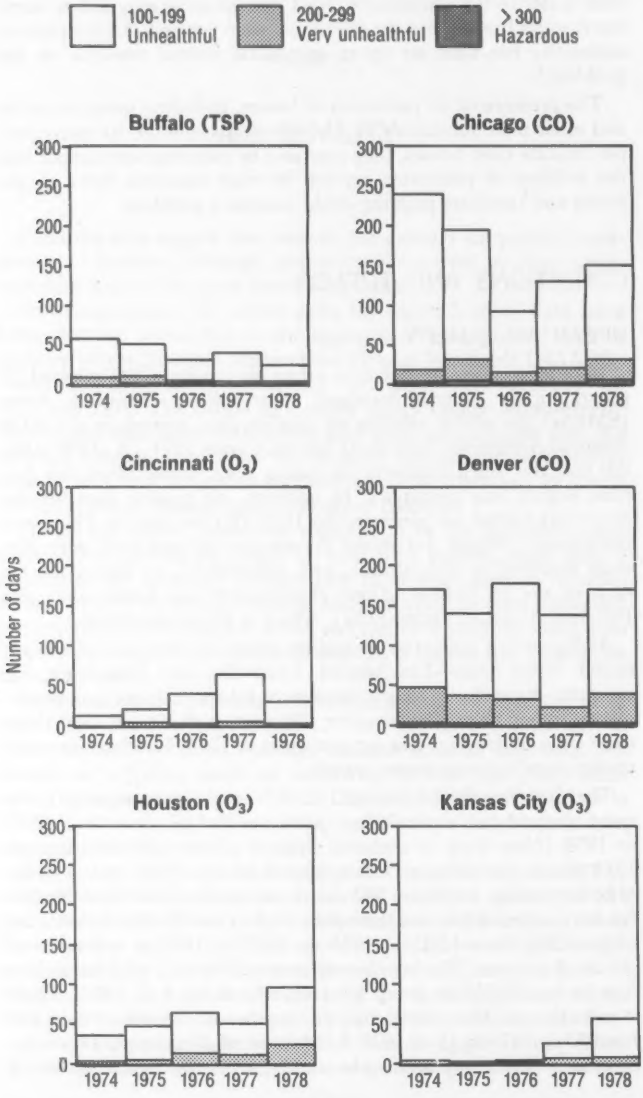


Figure 4-1 (continued)

Trends in PSI Levels in 23 SMSAs, 1974-78

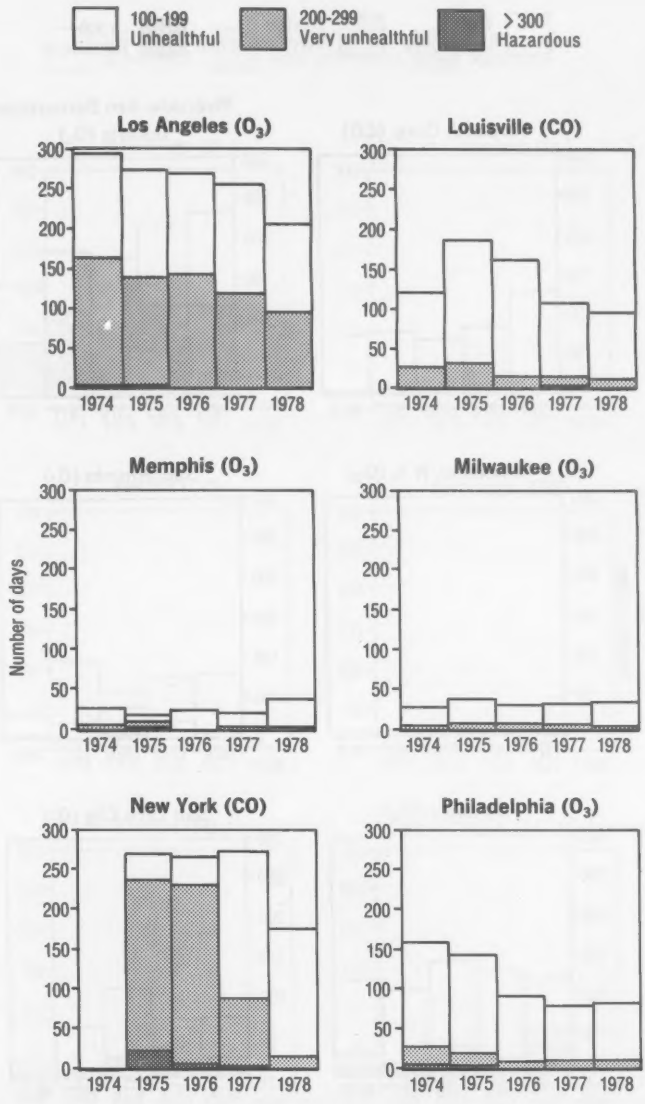


Figure 4-1 (continued)

Trends in PSI Levels in 23 SMSAs, 1974-78

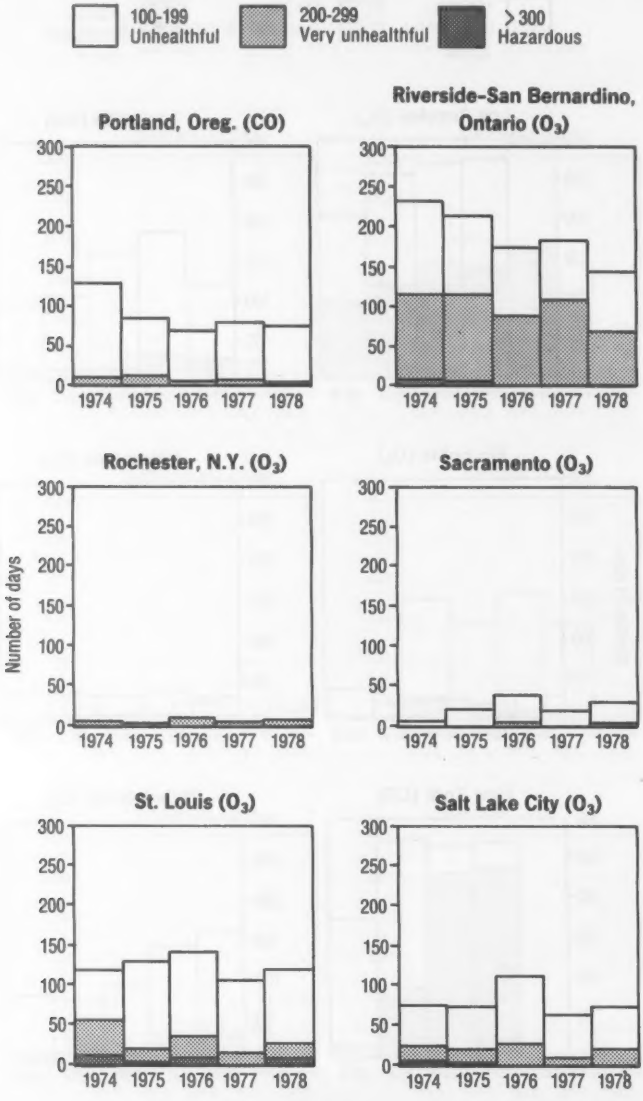


Figure 4-1 (continued)

Trends in PSI Levels in 23 SMSAs, 1974-78

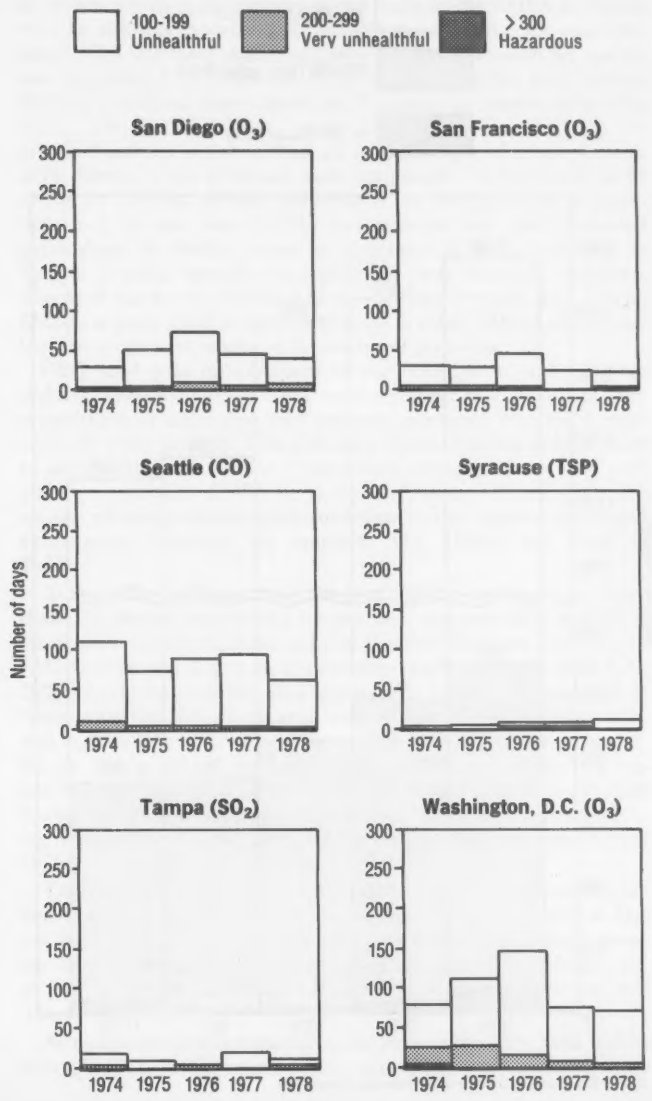
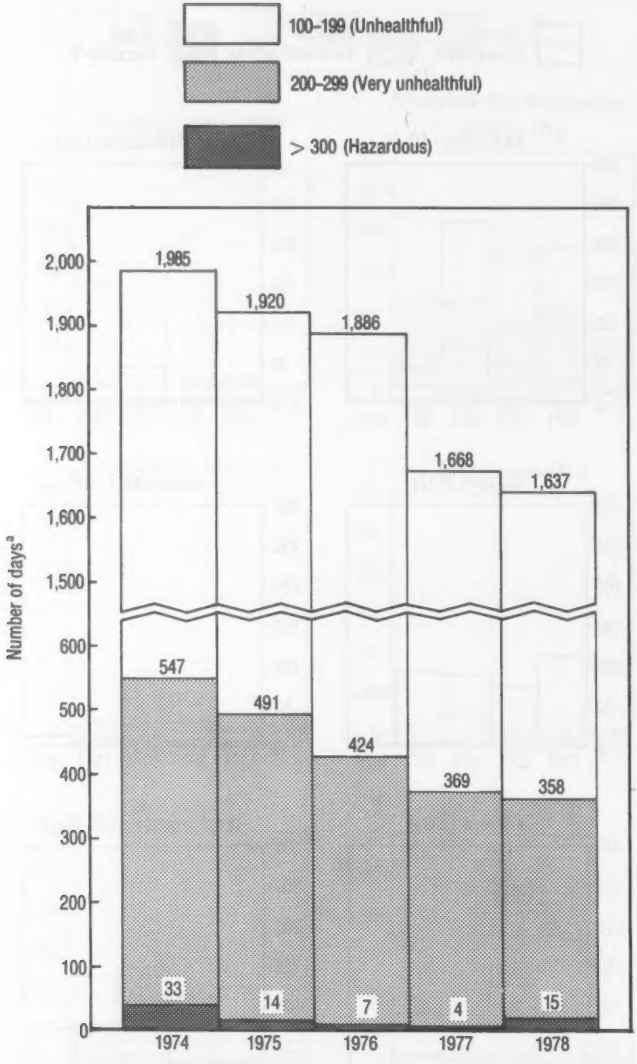


Figure 4-2

National Trends in Urban PSI Levels, 1974-78



[a]Combined total for 23 SMSAs.
Source: Based on U.S. Environmental Protection Agency data.

days in which the air was unhealthful or worse decreasing each year. Improvement has also been continuous as measured by the number of days in which air quality was very unhealthful.

The pollutant most often responsible for violations of the NAAQS in 1978 is shown in parentheses by the name of the SMSA in Figure 4–1. In the Los Angeles and Philadelphia SMSAs, for example, ozone (O_3) was most often responsible for days on which air quality was unhealthful or worse in 1978. In the Chicago and Denver SMSAs, violations were caused in the main by carbon monoxide (CO). The figure indicates clearly that O_3 and then CO are the principal culprits in unhealthful air in this sample of urban areas in 1978. Ozone is the pollutant most responsible for violations in 15 of the 24 SMSAs; carbon monoxide is the leading cause of violations in 6. In only two, Buffalo and Syracuse, are total suspended particulates the leading cause of violations in 1978, and only in Tampa is sulfur dioxide responsible for most NAAQS violations. The total number of violations in the Buffalo, Syracuse, and Tampa SMSAs is quite small compared to those in other SMSAs where carbon monoxide and ozone are the source of problems.

CEQ used data on violations of the NAAQS to rank 40 large SMSAs. The rankings are based on the number of unhealthful, very unhealthful, or hazardous days per year, averaged over the 3 years 1976–78 when possible. This averaging should remove at least some of the bias that would exist if data from one year alone were used and if a particular SMSA or group of SMSAs suffered from unusually adverse meteorological conditions in that year—a prolonged temperature inversion, for example. The SMSAs are listed in Table 4–1.

As the table indicates, there are four SMSAs that averaged more than 150 days of unhealthful air per year between 1976 and 1978. Particularly disturbing is the fact that the New York and Los Angeles SMSAs—the two largest in the country—each averaged more than 200 unhealthful days per year during the 3 years. During one of those years the New York area experienced 273 unhealthful days, and in its worst year the Los Angeles area had 268 days of unhealthful air. Air quality in the Los Angeles SMSA was in the very unhealthful or hazardous range for an average of 118 days per year during the 3 years. These data are a clear indication of the continuing very serious air pollution problems in Los Angeles from 1976 to 1978.

The data in Table 4–1 are not all discouraging. For example, the Grand Rapids (Michigan) SMSA averaged only 5 unhealthful days per year from 1976 to 1978. Dallas and Tampa, both rapidly growing SMSAs, each averaged fewer than 25 days of unhealthful air, as did the Akron, Norfolk, Rochester (New York), Syracuse, and Toledo SMSAs.

Although air quality remained quite poor in the New York SMSA through 1978, it was much better then than in the three previous

Table 4–1

Ranking of 40 Standard Metropolitan Statistical Areas Using the PSI, 1976–78

Severity level (PSI > 100)	SMSA	"Unhealthful," "very unhealthful," and "hazardous" (PSI > 100) (Number of days)		"Very unhealthful" and "hazardous" (PSI > 200) (Number of days)	
		3-yr avg	Min/max annual	3-yr avg	Min/max annual
More than 150 days	Los Angeles	242	206–268	118	95–142
	New York	224	174–273	51	14–87
	Pittsburgh [a]	168	168	31	168
	San Bernardino Riverside-Ontario	167	145–182	88	68–108
100–150 days	Cleveland	145	60–230	35	17–52
	St. Louis	136	119–164	29	17–44
	Chicago	124	81–150	21	14–31
	Louisville	119	94–160	12	8–14
50–99 days	Washington, D.C.	97	70–147	8	3–15
	Phoenix [b]	84	75–93	10	5–14
	Philadelphia	82	79–87	9	7–10
	Seattle	82	62–95	4	2–5
	Salt Lake City	81	61–110	18	9–25
	Birmingham [b]	75	50–100	19	8–29
	Portland	75	70–81	3	2–5
	Houston	69	50–94	16	11–24
	Detroit	65	62–68	4	2–5
	Jersey City [b]	65	56–74	4	0–8
	Baltimore	60	32–79	12	2–25
	San Diego	52	38–74	6	4–9
25–49 days	Cincinnati	45	30–63	2	1–4
	Dayton	45	32–66	2	1–2
	Gary-Hammond East Chicago	36	27–50	8	1–16
	Indianapolis	36	17–49	2	1–3
	Milwaukee	33	32–34	6	3–8
	Buffalo	31	23–40	5	3–8
	San Francisco	30	22–45	1	0–1
	Kansas City	29	7–56	5	1–9
	Memphis	28	22–37	2	0–3
	Sacramento	28	19–38	2	0–3
	Allentown [a]	27	27	1	27
0–24 days	Toledo	24	15–32	2	1–5
	Dallas	22	6–35	1	1–2
	Tampa	12	5–19	1	0–2
	Akron [b]	10	5–14	0	0–0
	Norfolk [b]	9	9–9	0	0–0
	Syracuse	9	7–12	1	0–2
	Rochester	6	4–8	0	0–0
	Grand Rapids	5	2–8	0	0–1

[a] Based on 1 year of data only.
[b] Based on 2 years of data only.

years. Not only did the total number of unhealthful or worse days there fall to 174 from the previous 3-year average of 270, but also the number of very unhealthful and hazardous days fell from 87 to 14 between 1977 and 1978. This followed the dramatic fall from 229 in 1976 to 87 in 1977. Thus, although there is still much room for improvement in New York, there are some encouraging signs.

Of the caveats about the PSI, discussed below, one deserves particular emphasis. There is no uniform procedure for siting air quality monitors in metropolitan regions. In some SMSAs monitors are sited very near major sources of air pollution so that authorities can assess the efficacy of their control programs. In other areas, some, and perhaps many, monitors are sited in very clean areas in order to detect background levels of pollution or to protect against degradation of these areas. The siting of monitors may have the spurious effect of making air quality in some SMSAs appear better than in others where the monitors are located near the pollution sources—when in fact air quality in the two areas could be quite similar. Such differences in locating monitors may account for some of the differences in the SMSA rankings.

POLLUTANT STANDARDS INDEX (PSI)

Five of the "criteria air pollutants"—sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), and total suspended particulates (TSP)—are monitored extensively. It would be difficult to present data on national trends in urban air quality or to rank SMSAs on the basis of air quality without an index that translates concentrations of these five pollutants into a single value. The Pollutant Standards Index converts data on ambient concentrations of five criteria pollutants into a single value on a scale of 0–500. The main purpose of the PSI is to present urban air quality data from across the nation on a consistent basis.[4] Table 4–2 describes each PSI value in terms of the possible human health effects.

When the levels of all five pollutants reflected in the PSI are below either their short-term primary National Ambient Air Quality Standards or the guideline value for NO_2 (for which no short-term standard has been proposed), the PSI ranges from 0 to 99 (air quality is "good" if the PSI is between 0 and 49; it is "moderate" if the PSI is between 50 and 99). As soon as the ambient concentration of any one of the five monitored pollutants rises above its NAAQS, the PSI registers a value of 100 or above. Depending on the PSI value (which in turn depends on the highest single value of any of the five measured pollutants), air quality is categorized as "unhealthful" (PSI of 100–199), "very unhealthful" (PSI of 200–299), or "hazardous" (PSI 300 or above). Table 4–2 also indicates the general health effects of air quality at various levels and includes cautionary statements regarding health effects.

Table 4–2

Comparison of PSI Values, Pollutant Levels, and General Health Effects

PSI value	Pollutant level					Descriptor	Health	
	TSP (24-hr) μg/m³	SO_2 (24-hr) μg/m³	CO (8-hr) mg/m³	O_3 (1-hr) μg/m³	NO_3 (1-hr) μg/m³		Effects	Warning
400 and above	875 and above	2,000 and above	46.0 and above	1,000 and above	3,000 and above	Hazardous	Premature death of ill and elderly. Healthy people will experience adverse symptoms that affect their normal activity.	All persons should remain indoors, keeping windows and doors closed. All persons should minimize physical exertion and avoid traffic.
300–399	625–874	1,600–2,099	34.0–45.9	900–1,099	2,260–2,999	Hazardous	Premature onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons.	Elderly and persons with existing diseases should stay indoors and avoid physical exertion. General population should avoid outdoor activity.
200–299	375–624	800–1,599	17.0–33.9	480–899	1,130–2,259	Very unhealthful	Significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease, with widespread symptoms in the healthy population.	Elderly and persons with existing heart or lung disease should stay indoors and reduce physical activity.

100–199	260–374	365–799	10.0–16.9	240–479	NR	Unhealthful	Mild aggravation of symptoms in susceptible persons, with irritation symptoms in the healthy population.	Persons with existing heart or respiratory ailments should reduce physical exertion and outdoor activity.
50–99	75[a]–259	80[a]–364	5.0–9.9	120–239	NR	Moderate		
0–49	0–74	0–79	0–4.9	0–119	NR	Good		

NR = No index values reported at concentration levels below those specified by "alert level" criteria.
[a] Annual primary NAAQS.

Source: U.S. Environmental Protection Agency, "Guideline for Public Reporting of Daily Air Quality—Pollutant Standards Index," 450/2–76–013 (Washington, D.C., 1976).

The PSI-based trends analysis presented in Figure 4–1 and the rankings in Table 4–1 depend upon several important and implicit assumptions. First, it is assumed that the entire SMSA experienced the air quality measured at the worst location in that area, as indicated by the PSI—that is, if the PSI at any one of a large number of monitors in an urban area registered above 100 on a particular day, that day was recorded as being unhealthful for the entire SMSA. This procedure is quite conservative—or pessimistic—and can have the result that if an isolated hot spot of pollution is always responsible for elevated PSI readings in an SMSA, air quality in large parts of the SMSA might be much less serious than the PSI would suggest.

Another problem relates to the frequency and accuracy of monitoring data.[5] Mindful of these problems, in May 1979 the Environmental Protection Agency (EPA) issued regulations creating a standardized national air quality monitoring system.[6] More than 1,200 National Air Monitoring Sites (NAMS) have been or will be created from the more than 5,100 state and local air monitoring sites that now comprise the national network for air quality monitoring. The NAMS will be subject to strict and uniform requirements and, when established, should solve some of the monitoring problems discussed here.

Of the NAMS, 636 will monitor TSP (including particle size and chemical composition), 244 will monitor SO_2, and 121 will monitor CO. EPA plans to eliminate some SO_2 sites and to reallocate resources to ensure the quality of the other data. Because of resource limitations, O_3 monitors will be located in metropolitan areas with more than 200,000 people; NO_2 monitors will be located in areas with more than 1 million people.

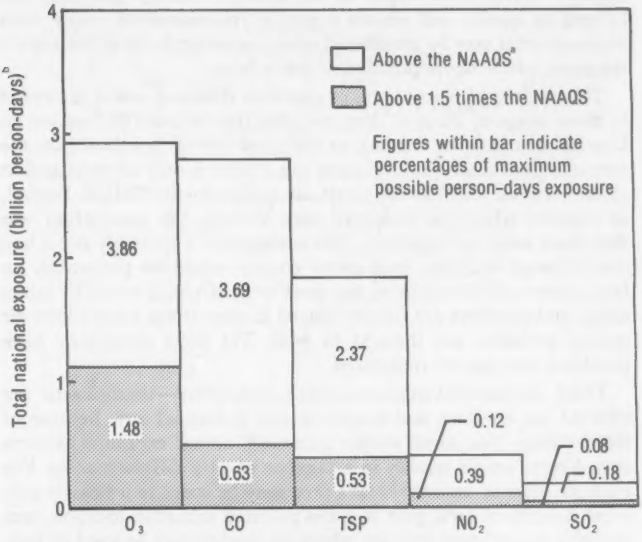
REGIONAL AIR QUALITY AND THE POPULATION AT RISK

The PSI can be used to examine regional as well as urban air quality. Combined with population data, it can be used to estimate the number of people exposed to air pollutants at levels above the national standards.

The Council combined 1978 PSI data with 1975 Census data on county populations. Population of a county was multiplied by the number of days in 1978 in which its air quality exceeded short-term national standards or, in the case of NO_2, a guideline standard of 500 $\mu g/m^3$. This calculation permits an estimate of person-days of exposure to unhealthful or worse air. The actual number of person-days of exposure to levels above the standards can be compared to the maximum possible number each year (207 million $\times$ 365 days $=$ 76 billion person-days) for each of the five monitored criteria pollutants. For example, as Figure 4–3 indicates, in 1978 there were approximately 2.92 billion person-days of actual exposure to ozone levels above the short-term primary standards; this number is ap-

Figure 4-3

Estimated National Exposures to Pollutants above the Short-Term Ambient Health-Related (Primary) Standards, 1978



[a]NO_2 analysis based on exposures above 0.266 ppm (500 $\mu g/m^3$).
[b]Maximum national exposure equals 76 billion person-days.
Source: Based on U.S. Environmental Protection Agency data.

proximately 3.9 percent of the maximum possible person-days of exposure (76 billion).

The corresponding ratio of actual to maximum possible person-days for carbon monoxide is 3.7 percent. The percentages were considerably lower for TSP, NO_2, and SO_2—2.4 percent, 0.4 percent, and 0.2 percent, respectively. Figure 4–3 also indicates person-days of exposure to pollutant concentrations in excess of 1.5 times the primary ambient standard compared to the maximum possible totals. These totals were also considerably higher for O_3 and CO in 1978 than for the other three pollutants. The relatively low ratio of actual to maximum possible person-days exposure to air pollution levels above the standards should not obscure the fact that in certain areas residents are sometimes exposed to high pollutant concentrations for extended periods.

Population exposure analyses are very important tools in overall air quality analysis. In fact, they are essential to understanding the

human health effects of changes in air quality because such effects depend upon both air quality and population at risk. For example, the effects on human health of reducing levels of SO_2 in a predominantly rural area will be negligible if, during the time when the improvements occurred, the population of the area dwindled to virtually nothing. (At the same time, the reduction in SO_2 levels might improve agricultural output in the area.) Although generally improved air quality will remain a goal of environmental policy, such improvements may be considered most important in large metropolitan areas where the population at risk is large.

The analysis of person-days of exposure discussed above is limited in three respects. First, it does not take into account differences in location of monitors; further, as discussed above, it is based on the assumption that air quality in any one SMSA is only as good as that at the location that has the worst air quality in the SMSA. Second, in counties where no monitors were located, the assumption was that there were no violations. This assumption is probably not a bad one although readings from every county would be preferable. In fact, almost all violations of the short-term NAAQS occur in urban areas, and monitors are usually placed in non-urban areas where air quality problems are thought to exist. Yet some areas may have problems that are not monitored.

Third, the analysis assumes a static population—that all who are affected are outdoors and remain in one county all day. Because of the distances that some people commute, actual exposure patterns may depend on air quality in a number of very different areas. For example, part of an individual's time may be spent in a heavily polluted downtown area, part in a less polluted suburban location, and probably a good part indoors, where air quality may be good or bad. Thus, overall exposure may not be adequately represented by county-level data, although such data appear to be the best available for the time being.

CEQ also examined air quality data for indications of regional variations in air quality in 1978. This analysis once more confirms the fact that violations of the short-term O_3 and CO standards are more widespread, frequent, and severe than violations of the short-term standards for TSP and SO_2 and the guideline value for NO_2.

Figure 4–4 shows the federal air pollution control regions, and Table 4–3 shows the number of counties in each region that monitor for at least one of the five criteria pollutants. For each of the five pollutants, Table 4–3 indicates what percentage of the counties monitoring for a particular pollutant experienced any violations of the short-term primary NAAQS in 1978 and what percentage of those counties experienced 10 or more days of violations. For example, in the eight southeastern states of Region IV, 298 counties monitor for at least one of the five pollutants. Fifty-eight percent of the counties monitoring for CO in Region IV experienced at least 1 violation of the NAAQS for CO, and 23 percent experienced 10 or more. Only

Figure 4-4

Federal Air Pollution Control Regions

8 percent of the counties in Region IV with SO_2 monitors detected violations, however, and none experienced 10 or more violations.

The results of this analysis re-emphasize the importance of carbon monoxide and ozone (or photochemical oxidants) in overall air quality problems. In 1978, all regions had violations of the short-term primary NAAQS for CO in at least 28 percent of the counties that monitored for it. In Region X, 89 percent of the counties monitoring CO had at least 1 violation of the CO standard, and 67 percent had at least 10 violations. The picture is even worse for photochemical oxidants. In only one federal region (Region VII, comprising Iowa, Missouri, Nebraska, and Kansas) were more than one-half the counties monitoring for ozone free of violations of the ozone standard. In 5 of the 10 regions, at least three-quarters of the counties experienced violations.

The problems associated with violations of the NAAQS for TSP, NO_2, and SO_2 are generally less pronounced. Exceptions are Regions V–X, where violations of the TSP standard resulted in part from windblown dust and other natural sources. However, very few of the counties reporting experienced more than 10 days of violations for any of these pollutants.

Table 4–3

Frequency of Violations for the 10 Federal Regions by Criteria Pollutants, 1978

		Federal region									
		I	II	III	IV	V	VI	VII	VIII	IX	X
Number of counties with monitoring data for at least one criteria pollutant		41	83	147	298	225	129	61	130	70	71
Carbon monoxide	Percentage with violations of NAAQS	73	55	43	58	64	28	62	82	50	89
	Percentage with 10 or more days of violations	55	21	8	23	28	11	31	53	19	67
Photochemical oxidants	Percentage with violations of NAAQS	76	81	79	67	79	96	46	50	60	50
	Percentage with 10 or more days of violations	29	31	47	12	34	35	31	10	30	0
Nitrogen dioxide	Percentage with violations of NAAQS	0	9	21	13	18	8	40	5	22	0
	Percentage with 10 or more days of violations	0	0	4	0	0	0	20	0	3	0
Sulfur dioxide	Percentage with violations of NAAQS	7	5	4	8	14	1	6	9	13	14
	Percentage with 10 or more days of violations	10	0	1	0	3	0	0	7	7	0
Total suspended particulates	Percentage with violations of NAAQS	10	11	12	8	27	24	32	29	38	40
	Percentage with 10 or more days of violations	0	2	1	1	5	3	4	2	7	1

TRENDS IN AMBIENT CONCENTRATIONS

As in the past several years, CEQ described air quality conditions and trends in terms of the frequency and severity of violations of the short-term primary (health-based) NAAQS. Trends in violations of short-term standards are a most important way of indicating progress in air quality management. They are important because State Implementation Plans are designed to regulate sources in order to meet the statutory requirement that short-term air quality standards be violated no more than once each year in each air quality control region. Examining the frequency of violations (defined by the highest daily concentration), then, is a necessary check on the success of state efforts.

Trends in violations are not the only way to characterize air quality trends, however. This year CEQ also examined trends in average ambient concentrations of four criteria pollutants at a large number of sites throughout the country. Before the trends are presented, it is first useful to discuss briefly their value as indicators of air quality.

Over the course of a year or a month—or even a single day—pollutant concentrations can vary markedly at a particular site. Thus trends in air quality at that site could be described by the highest readings and their relationship to standards—this is the PSI approach described above and used in the preceding analysis. Alternatively, air quality could be described by the average (or mean) of a whole day's or month's readings, the most frequently observed value (the mode), or any number of other summary measures.

The choice of one particular measure over another is important because it might mean the difference between a favorable and an unfavorable trend. For example, if an increase in the number of readings above a standard were more than offset by an even greater increase in low readings, the average concentration to which individuals were exposed might decrease in spite of the increase in violations of a standard. Because it may be beneficial to reduce human exposures to pollutants even at levels below the primary standards, trends in concentrations can indicate progress in this direction while data on violations cannot.

With these distinctions in mind, it is instructive to consider the national trend in average ambient concentrations of ozone, the pollutant most responsible for violations of the national standards. The Council selected 23 sites in California and 28 sites in other states for which adequate data were available. The criteria for selection were that a site must have had no more than 30 consecutive unmonitored days from April through June and must have monitored at least 80 percent of the days between July and September for all 5 years from 1974 through 1978. The 3 months of July-September were used because ozone concentrations are highest

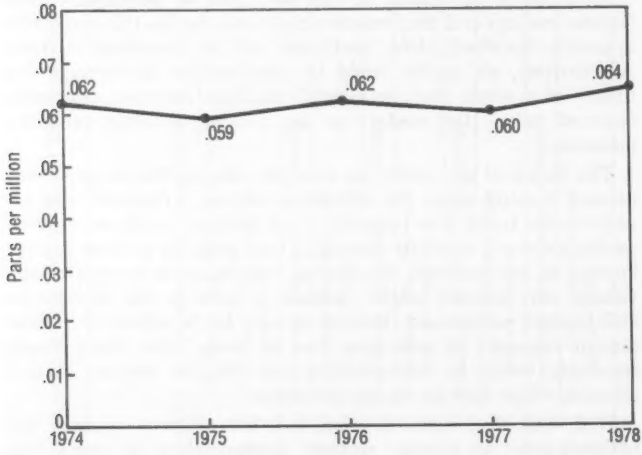
during the summer when sunlight stimulates the production of ozone from the interaction of hydrocarbons and nitrogen oxides.*

As shown in Figures 4–5, 4–6, and 4–7, for all intents and purposes there have been no changes for 5 years in the average daily maximum ozone readings at either the California or non-California sites. Although average concentrations were slightly higher in 1978 than in 1977 in California, 0.064 parts per million versus 0.060 ppm, the difference is small. Similarly, for the 28 non-California sites, the trends show little change. The average for these sites, 0.045 ppm ozone, has remained constant for 3 years. As Figure 4–7 shows, when the two subsamples are pooled, the combined trend is still virtually flat, although it increased slightly from 1977 to 1978, reflecting the very slight upward trend in California.[7]

The current primary national ambient air quality standard for ozone is 0.12 ppm averaged over 1 hour, having been increased

Figure 4-5

Annual Mean of Daily Maximum Ozone Concentrations at 23 California Sites, 1974-78

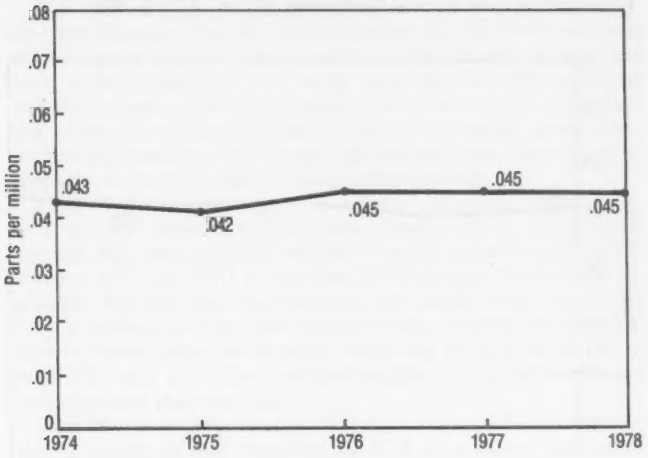


Source: Based on U.S. Environmental Protection Agency data.

* The averaging procedure was as follows: first, for each site the highest 1-hour reading for each day was used to characterize that day, the high-hour readings for all the days monitored in the year were averaged, and then the averages for the 23 California sites and the 28 other sites were calculated from the individual site averages.

Figure 4-6

Annual Mean of Daily Maximum Ozone Concentrations at 28 Non-California Sites, 1974-78



Source: Based on U.S. Environmental Protection Agency data.

to that level from 0.08 ppm in 1979. Thus, in spite of the slight upward turn in the California and the pooled samples between 1977 and 1978, the average concentrations are well below the national standard. However, it is still true that during certain parts of the year (summer, especially), readings at some of the sites are well above the standard. These high readings remain a source of concern.

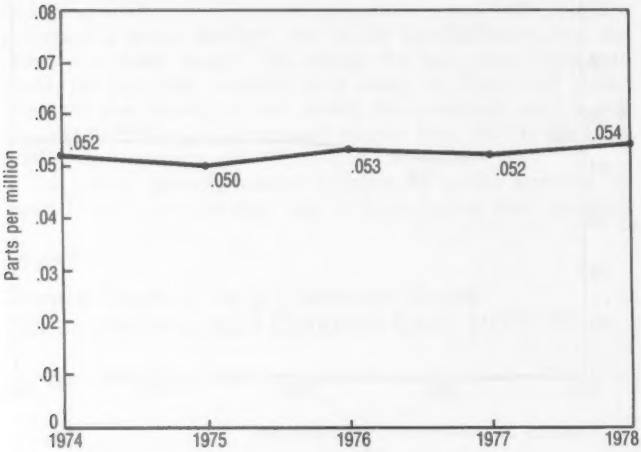
In contrast to ozone, carbon monoxide has shown continual and substantial improvement during the last 6 years. As Figure 4–8 shows, the average annual concentration in 1978 was 33 percent below that of 1973. The sites analyzed for CO were those for which data were available for at least four consecutive quarters from 1973 to 1975 and from 1976 to 1978. Further, in each of the consecutive quarters in both periods, at least 80 percent of the days must have been monitored.

These criteria were met each year at as few as 68 and as many as 113 sites monitoring for carbon monoxide between 1973 and 1978. Figure 4–8 shows the trend in the annual arithmetic average of daily maximum 8-hour concentrations of CO. As observed, the number of sites varies from year to year because some sites met the test in some years but not in others.

The primary 8-hour national ambient air quality standard for CO is 9 ppm; thus the annual average concentration at the sites

Figure 4-7

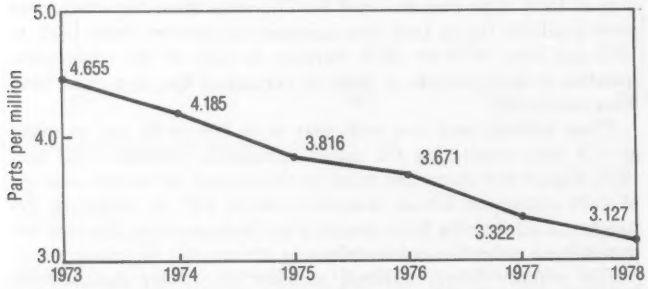
Annual Mean of Daily Maximum Ozone Concentrations from Composite Average of California and Non-California Sites, 1974-78



Source: Based on U.S. Environmental Protection Agency data.

Figure 4-8

Annual Arithmetic Average of Daily Maximum 8-Hour CO Concentrations, 1973-78



Number of sites included in the sample range from 68 to 113.

included in the CEQ sample has fallen from about one-half that level to nearly one-third of the standard. If the sites included in the CEQ trend analysis are representative of most CO monitoring sites, the trend is most encouraging.

It is often difficult to pinpoint the exact causes of changes in ambient concentrations. Several factors may account for the reduced concentrations of CO. First, emissions control devices on new cars have probably reduced CO levels, especially in traffic-saturated downtown areas where vehicle miles traveled are unlikely to increase and offset reduced emissions per vehicle mile. Further, prohibitions on burning municipal solid wastes and reduced agricultural burning probably account for some reduced concentrations.

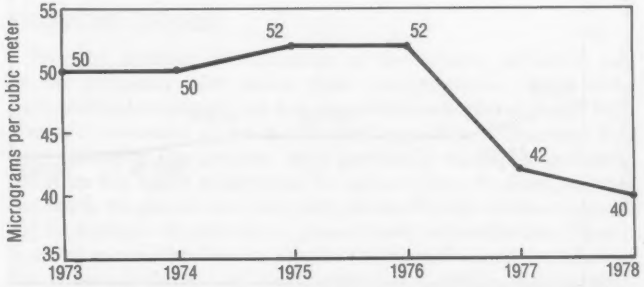
Figure 4–9 shows the trend in the annual arithmetic mean of 24-hour average concentrations of sulfur dioxide (SO_2). The annual average SO_2 concentration declined from 50 $\mu g/m^3$ to 40 $\mu g/m^3$ between 1973 and 1978, a reduction of 20 percent. The criteria for selecting the sites were the same as those used in the analysis of carbon monoxide trends. The number of sites satisfying the selection criteria varied from year to year—from only 23 in 1973 to 170 in both 1975 and 1976. The average number of sites included each year over the 6 years was 128.

This 20 percent reduction in the annual average SO_2 concentration is similar to that identified by EPA in a recent analysis of pollutant concentrations using a different set of sites.[8] EPA found a 67 percent reduction in SO_2 concentrations between 1964 and 1979. Of this reduction, 55 percent occurred between 1964 and 1971, and about 15 percent occurred between 1973 and 1978.

The reduced SO_2 concentrations identified in both the CEQ and EPA analyses are probably at least partly a result of the shift from

Figure 4-9

Annual Arithmetic Mean of 24-Hour Average SO_2 Concentrations, 1973-78



Number of sites included in the sample range from 23 to 170.

burning high sulfur coal and fuel oil to burning natural gas and lower sulfur coal and fuel oil in homes and in industrial and utility boilers. Some of the improvement may also result from the relocation of some sources of SO_2 emissions away from urban areas where SO_2 is monitored.

The annual primary standard for SO_2 is 80 $\mu g/m^3$. The CEQ analysis shows that the annual average SO_2 concentration at the sites selected is well below that level and is declining.

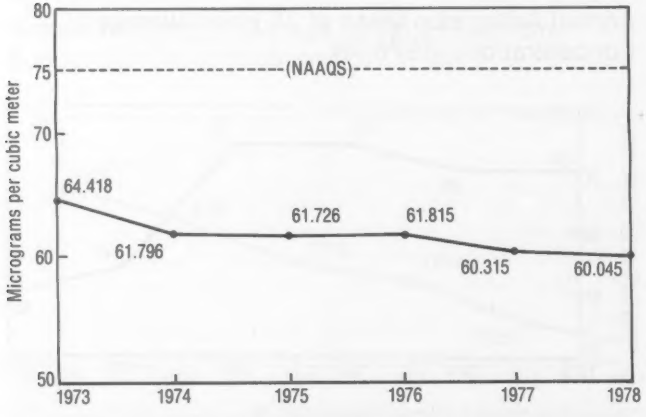
During the 6 years from 1973 to 1978, the average annual TSP concentration decreased about 7 percent, with the largest reduction between 1973 and 1974. The criteria for inclusion of TSP sites in the CEQ trends analysis were similar to those for CO and SO_2. An average of 1,175 sites satisfied the criteria each year. The data from these sites are shown in Figure 4–10.

The annual primary standard for TSP is 75 micrograms per cubic meter ($\mu g/m^3$). The annual concentration averaged over the sites in the CEQ analysis is between 14 percent (in 1973) and 20 percent (in 1978) below the standards. In spite of this national trend, however, it has proved difficult to reduce annual average TSP concentrations much below the primary standard in many areas. In fact, according to EPA, about 20 percent of the people in the United States live in areas where the annual TSP standard has not yet been met.[9]

EPA has recently examined data on TSP concentrations at a sample of sites that goes back to 1960. For those sites, EPA found

Figure 4-10

Annual Geometric Mean Average TSP Concentrations, 1973-78



Number of sites included in the sample range from 1,066 to 1,518.

that the annual concentration of TSP has declined about 32 percent between 1960 and 1979.[10] Like CEQ, EPA found about a 7 percent reduction in annual average TSP concentrations between 1973 and 1978. This reduction is probably a function of controls on industrial facilities and other stationary sources of emissions, although variations in particulate concentrations are also sensitive to natural sources like windblown and re-intrained road dust, wildfires, and volcanic activity (of which there was little between 1973 and 1978).

In addition to the criteria for selecting the CO, SO_2, and TSP sites discussed above, several more restrictive criteria were applied to the data to test the sensitivity of the national trends. (For example, a set of sites was examined for which much more complete data were required; similarly, another and larger set of sites was selected on the basis of less restrictive criteria for data completeness.) Varying the site selection criteria had little effect on the national trends for these three criteria pollutants. However, for NO_2, one set of criteria for site selection resulted in a trend showing increases in NO_2 concentrations, a slightly different set of criteria revealed little change between 1973 and 1978 in NO_2 concentrations, and a third set showed ambient concentrations of NO_2 decreasing steadily between 1973 and 1978. Because the trend in annual NO_2 concentrations appears to be so sensitive to selection criteria when there are insufficient data, it is not included this year.

Overall, national trends in annual average concentrations of CO, SO_2, TSP, and O_3 confirm the trends in violations. Air quality appears to be improving. Based on CEQ trends analysis, the improvement in CO appears to be more pronounced than that for SO_2 and TSP; ozone concentrations remain about constant. The annual average concentrations are all below the primary national standards as well, less so for TSP than either CO or SO_2. But, as in the case of the violations data, averaging can conceal local problems that may require special control measures. Such local measures should be the focus of additional effort by EPA and state air pollution authorities.

EMISSIONS TRENDS

Data on ambient concentrations of the criteria pollutants and on the frequency with which these concentrations violate short-term national standards are two important indications of the location and seriousness of air quality problems. But, as discussed in a later section of this chapter, some potentially damaging pollutants fall from the upper atmosphere in rain or snow. In doing so, they can reach the ground far from their places of origin without appearing in measures of ambient or ground level concentrations. Thus it is useful to consider data on actual or estimated annual emissions of the criteria pollutants or their precursors (volatile organic compounds, in the case of ozone, which is not emitted directly). Such

information may call attention to air quality problems not directly related to ambient air quality as measured at SMSA or other monitoring sites and, over time, may indicate pollution controls that are effective.

It is important to understand that natural sources contribute to total annual emissions of the criteria pollutants. Nothing could illustrate this more dramatically than the May 1980 eruption of the long-dormant Mount St. Helens in Washington. The volume of SO_2 and particulate matter discharged cannot be determined with any degree of confidence. Nevertheless, in the days before the first major eruption, the volcano was emitting an estimated 3–30 tons of SO_2 per day.[11] Seaspray, lightning, wildfires, windblown dust from the desert, denitrification of fertilizers, decomposition of organic matter, and emissions from vegetation contribute to total annual emissions of all five criteria pollutants.

Table 4–4 presents EPA *estimates* of national manmade emissions from 1970 to 1978 of four criteria pollutants—SO_2, TSP, NO_x, and CO—and of volatile organic compounds (or hydrocarbons) which are the precursors of total oxidants, including ozone. With the exception of nitrogen oxides, estimated total emissions of these pollutants were either constant or decreasing in the 9 years. For particulates, produced mainly by fuel combustion at factories and power plants, estimated annual emissions have dropped significantly.

It is important to remember that these figures are estimates of emissions, based on inventories of sources coupled with estimates of annual emissions per source, rather than measurements of emissions. Second, national trends can mask very different local and regional

Table 4–4

National Emissions Estimates, 1970–78
(million metric tons per year)

Year	TSP	SO_2	NO_2	Volatile organic compounds	CO
1970	23.2	29.8	19.9	28.3	102.6
1971	22.0	28.2	20.6	27.8	103.1
1972	21.0	29.3	21.6	28.3	104.4
1973	20.3	30.4	22.4	28.4	103.5
1974	17.9	28.5	21.8	27.1	99.6
1975	14.6	26.2	20.9	25.3	97.2
1976	14.1	27.4	22.5	27.0	102.9
1977	13.6	27.2	23.4	27.1	102.4
1978	12.5	27.0	23.3	27.8	102.1
Percentage change, 1970–78	− 46.1	− 9.4	+ 17.1	− 1.8	− 0.5

1 million metric tons = approximately 1.1 million short tons.

Source: U.S. Environmental Protection Agency, *National Air Pollutant Emission Estimates, 1970–1978*, EPA–450/4–80–002 (Washington, D.C., 1980), p. 2.

trends—increased emissions in some areas can be more than offset by reduced emissions in others, producing a declining national trend that may obscure emissions increases in some areas that may be contributing to air quality problems.

As Table 4–4 indicates, EPA estimates that annual manmade emissions of total suspended particulates were cut nearly in half between 1970 and 1978. EPA ascribes the improvement to the installation of control technology at coal-fired utility and industrial boilers and the prohibitions on open burning of solid wastes. EPA's estimated 9.4 percent decrease in SO_2 emissions is attributed to the use of lower sulfur fuels for home heating and for utility and industrial combustion and to reduced emissions from nonferrous metal smelters and plants manufacturing sulfuric acid.

Estimated emissions of volatile organic compounds (VOC) decreased slightly from 1970 to 1978. According to EPA, equipping cars with catalytic converters reduced motor vehicle emissions 10 percent. The gains were partially offset by increases in emissions from industrial sources and by increases in the number of vehicle-miles traveled.

Estimated carbon monoxide emissions remained about constant during the 8 years. According to EPA, increased CO emissions from motor vehicles were offset by reduced CO emissions from the burning of solid wastes and from rural agricultural fires. The estimated increase in CO emissions from automobiles does not necessarily mean that exhaust controls were ineffective. Working against improvements in CO emissions per vehicle-mile was the increase in the number of vehicle-miles traveled. According to EPA, had vehicle-miles traveled remained at 1970 levels (they increased 30 percent), carbon monoxide emissions would have fallen 25 percent by 1978.[12]

These estimates suggest that emissions depend not only on pollution controls but also on factors unrelated to environmental regulation. For example, between 1973 and 1975, estimated emissions of all five pollutants fell—even NO_x, which increased 17 percent from 1970 to 1978. A likely explanation is that the Arab oil embargo of 1973 and the subsequent recession in economic activity and increase in gasoline prices affected industrial output and miles-traveled in motor vehicles and—therefore—emissions.

Understanding these other influences on emissions and ambient concentrations is extremely important. Only when contributions of meteorological, economic, and other influences on air quality can be determined can the effects of present control measures be isolated. The inability to single out the effects of control measures on air quality is a major deficiency in current analyses.

CURRENT ISSUES

NATIONAL AMBIENT AIR QUALITY STANDARDS

EPA was required by the 1977 Clean Air Act amendments to

review the primary and secondary standards for the five major criteria pollutants—sulfur dioxide (SO_2), nitrogen dioxide (NO_2), total suspended particulates (TSP), carbon monoxide (CO), and ozone (O_3) (also referred to as photochemical oxidents).[13] This review—as well as any changes in the standards that might result from it—was to be completed by the end of 1980. Table 4–5 shows the existing and proposed new standards for the criteria pollutants.

The 1979 Annual Report discussed revision of the NAAQS for ozone. Briefly, in January 1979, the primary and secondary ozone standards were revised from 0.08 ppm averaged over 1 hour to their current levels of 0.12 ppm. The second criteria pollutant to be addressed in the revision process was carbon monoxide. In August 1980, EPA proposed that the maximum allowable 1-hour concentration of CO be reduced from 35 to 25 ppm.[14] No change was proposed for the longer-term, 8-hour standard from its present level of 9 ppm. The more stringent 1-hour standard was based on the need to protect people with heart ailments, especially during periods of moderate exercise, like walking. Following a review of public comment on the proposed standard, EPA will announce a final CO standard.

Table 4–5

National Ambient Air Quality Standards

Pollutant	Averaging time	Primary standard levels	Secondary standard levels
Particulate matter	Annual (geometric mean)	75 μg/m³	60 μg/m³
	24 hrs [b]	260 μg/m³	150 μg/m³
Sulfur oxides	Annual (arithmetic mean)	80 μg/m³ (0.03 ppm)	—
	24 hrs [b]	365 μg/m³ (0.14 ppm)	—
	3 hrs [b]	—	1300 μg/m³ (0.5 ppm)
Carbon monoxides	8 hrs [b]	10 mg/m³ (9 ppm)	10 mg/m³ (9 ppm)
	1 hr [b]	40 mg/m³ [a] (35 ppm)	40 mg/m³ [a] (35 ppm)
Nitrogen dioxide	Annual (arithmetic mean)	100 μg/m³ (0.05 ppm)	100 μg/m³ (0.05 ppm)
Ozone	1 hr [b]	240 μg/m³ (0.12 ppm)	240 μg/m³ (0.12 ppm)
Hydrocarbons (nonmethane) [c]	3 hrs (6 to 9 a.m.)	160 μg/m³ (0.24 ppm)	160 μg/m³ (0.24 ppm)
Lead	3 mos	1.5 μg/m³	1.5 μg/m³

[a] EPA has proposed a reduction of the standard to 25 ppm (29 mg/m³).
[c] A nonhealth-related standard used as a guide for ozone control.
[b] Not to be exceeded more than once a year.

Source: Information provided by the U.S. Environmental Protection Agency.

As directed by the Congress in the 1977 amendments to the Clean Air Act, EPA is considering a proposed standard limiting short-term exposures (3 hours or less) to NO_2.[15] No such standard exists. The long-term standard limits annual average concentrations of NO_2 to 100 $\mu g/m^3$. The final criteria document discussing the human health as well as the welfare effects of both long- and short-term exposures to NO_2 was expected to be available in late 1980. Because any proposed new standards for NO_2 must be based on a final criteria document, the standards are unlikely to appear before 1981.

Any proposed changes in the NAAQS for SO_2 and TSP that might result from the review of the existing standards will be even later in coming. A draft of the criteria document for sulfur oxides (including SO_2) and particulate matter was circulated for public comment in April 1980.[16] EPA is not expected to propose any new standards for SO_2 or TSP until early or mid-1981.

In addition to the appropriateness of the existing standards, other issues may be considered during the revision of the SO_2 and TSP standards. For example, EPA has pointed out that some members of the scientific community are unhappy with an air quality standard for particulates that does not take into account particle size.[17] As a result, EPA will look carefully at all available evidence bearing on whether "inhalable particulates"—those less than 15 micrometers long—are more harmful than larger particles because of their ability to reach the lung. Further, according to some scientists, "fine" particles—2.5 μm or less—may be particularly harmful. One possibility to be considered in revising the particulate standard, then, is the establishment of a standard for inhalable particulates. Such a standard could either replace or supplement the existing standard, which is based on total suspended particulates regardless of size.

Another issue being considered during the revision process is whether a short-term standard for SO_2 (limiting exposures over 1–3 hours) should be proposed. None exists; rather, EPA has established a standard limiting human exposure averaged over 24 hours and an annual standard as well. The possibility of establishing a short-term standard arises because some scientific evidence suggests that short-term exposures to high SO_2 concentrations may be responsible for adverse health effects.[18] EPA will also be considering whether a sulfur oxides standard should be based on sulfates or sulfuric acid in addition to or in place of the existing standard based on SO_2.

LONG-RANGE TRANSPORT AND ACID RAIN

The last Annual Report identified acid rain as one of the two most serious global environmental problems associated with the combustion of fossil fuels (carbon dioxide buildup is the other). Unfortunately, acid rain may be very difficult to control.

Under the Clean Air Act, ambient concentrations of the criteria pollutants within an air quality control region (AQCR) are to be brought within the national standards through controls imposed on the sources of those pollutants *within that AQCR.*[19] If a particular AQCR (there are 247 nationally) has a problem with ambient concentrations of sulfur dioxide (SO_2), the problem is to be addressed in the State Implementation Plan (SIP) by control measures imposed on the sources of SO_2 in that region.

This statutory arrangement creates two problems. First, SO_2 and NO_2 problems are not always reflected in ambient concentrations. When SO_2 and NO_2 are emitted, particularly from tall smoke stacks, these gases often rise high into the atmosphere where they can remain for days. There some of the SO_2 and NO_2 is transformed into sulfate and nitrate aerosols through a process that is now coming to be understood better. The aerosols can then combine with water vapor in the air (in the form of dew, rain, or snow) to form sulfuric acid or nitric acid. The acid may then fall to earth in wet form, or dry sulfate and nitrate particles can fall. Because they are no longer in their gaseous form, the oxides of sulfur and nitrogen do not show up on monitors of ambient concentrations. Control strategies based on ambient concentrations may therefore miss pollutants that only briefly pass through ambient air on their way to earth where they can have damaging effects.

Even when sulfur and nitrogen oxide emissions do affect ambient concentrations in a particular AQCR, their control presents other difficulties because of long-range transport. Thus air pollution in one region may be related not only to emissions in that region but also to emissions from sources well beyond the reach of the region's control authorities. The practice of permitting pollutant dispersal through tall stacks to avoid ground-level concentrations has resulted in the air-mailing of pollutants from some AQCRs to other areas where they are difficult to control.

Section 126 of the Clean Air Act empowers EPA to disapprove a SIP if it allows a source within the state to contribute to violations of the NAAQS in another state.[20] As pointed out above, this provision does not help when emissions in one place create wet acidic fallout elsewhere. Further, it is sometimes very difficult to determine the source of "foreign" pollutants which have been transported long distances. Therefore EPA may not know whose SIP to disapprove even when it knows that a problem in one region has an external source.

Contributing to the likelihood of chemical conversion and the long-range transport of pollutants are tall stacks at some point sources. The taller the stack from which hot flue gases are emitted, the higher the gases rise into the atmosphere. The resulting dispersion reduces ambient or ground-level concentrations of the pollutants and protects against some of the adverse health and welfare effects associated with such concentrations. Indeed, this is the purpose of

the tall stacks. But what goes up must generally come down, so that problems may appear elsewhere.

Tall stacks are not an isolated phenomenon. As Table 4–6 shows, an estimated 429 stacks taller than 61 meters (200 feet) have been built since 1970, 283 of them by electric utilities. Of the latter, 171 stacks exceed 152 meters (500 feet), and 34 exceed 244 meters (800 feet). This last group includes at least a half-dozen electric utility stacks that are taller than 1,000 feet, the tallest nearly a quarter-mile high.

Table 4–6

Estimated Number of Tall Stacks Constructed in the United States 1970–79

Stack height (feet)	Source category					
	Electric utilities	Smelters	Pulp and paper	Steel	Oil, gas and chemical	Total
≥ 800	34	2	—	—	—	36
700–799	37	1	—	—	—	38
600–699	45	1	1	—	—	47
500–599	55	0	—	—	3	57
400–499	55	0	2	—	4	61
300–399	34	1	12	2	11	60
200–299	23	3	34	4	65	129
Total	283	8	49	6	83	429

Source: H.E. Cramer Co., Inc., "Identifying and Assessing the Technical Bases for the Stack Height Regulatory Analysis," prepared for the U.S. Environmental Protection Agency, 1979.

Table 4–7 indicates the geographic distribution of electric utility stacks in excess of 152 meters, as estimated by the Department of Energy and the Federal Aviation Administration. Although they differ on the exact number and location, both identify the East North Central, South Atlantic, East South Central, and Middle Atlantic regions as major locations of the stacks. Most of the tallest, those in excess of 244 meters (800 feet), are in the East North Central and South Atlantic regions. This point is significant because prevailing winds may be carrying emissions of SO_2 and NO_x from these regions into New England and Canada, where the emissions may return to earth as acid deposition.

The 1977 amendments to the Clean Air Act directed EPA to propose regulations governing stack heights.[21] This provision was designed to address the practice of building tall stacks to disperse pollutants widely in order to meet local ambient standards. In January 1979, EPA proposed regulations defining "good engineering

Table 4–7

Regional Distribution of Tall Stacks Built by Electric Utilities 1970–79

Region	Stack height (ft)				Total
	≥ 800	700–799	600–699	500–599	
New England [a]	—	—	—	7	7
Middle Atlantic [b]	2	7	7	5	21
East North Central [c]	11	4	11	27	53
West North Central [d]	1	5	7	5	18
South Atlantic [e]	15	9	7	8	39
East South Central [f]	8	6	7	8	29
West South Central [g]	—	1	3	1	5
Mountain [h]	—	—	3	4	7
Pacific [i]	—	—	1	—	1
Total	37	33	46	70	186

[a] Includes Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.
[b] Includes New Jersey, New York, and Pennsylvania.
[c] Includes Illinois, Indiana, Michigan, Ohio, and Wisconsin.
[d] Includes Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota.
[e] Includes Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia.
[f] Includes Alabama, Kentucky, Mississippi, and Tennessee.
[g] Includes Arkansas, Louisiana, Oklahoma, and Texas.
[h] Includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming.
[i] Includes California, Oregon, and Washington.

Source: H.E. Cramer Co., Inc., "Identifying and Assessing the Technical Bases for the Stack Height Regulatory Analysis," prepared for the U.S. Environmental Protection Agency, 1979.

practice" in stack height (in other words, determining the maximum stack height a source would be permitted to use to meet local ambient standards).[22] Final regulations—which could affect long-range transport of air pollutants—are expected by the end of 1980.

Several steps have been taken to increase the information available about the sources, formation, transport, effects, and possible control of acid rain. One of the most important of these was creation of the interagency Acid Rain Coordination Committee. Formed by order of President Carter in his Environmental Message to Congress in August 1979,[23] the Committee began meeting in late 1979. Its members represent the Departments of Agriculture, Commerce, Energy, Interior, and State, the Council on Environmental Quality, the Environmental Protection Agency, the National Science Foundation, the Office of Science and Technology Policy, and the Tennessee Valley Authority. EPA and Agriculture cochair the Committee and CEQ is the Executive Secretary. The major responsibility of the group is the planning and management of a Federal Acid Rain Assessment Program.

In 1980, the Congress created the Acid Precipitation Task Force and charged it with virtually the same responsibilities as those of the Acid Rain Coordination Committee.[24] The membership and organization of the two groups differ only slightly; along with EPA and Agriculture, the National Oceanic and Atmospheric Administration cochairs the Task Force. Members of the Task Force will also include the directors of the four national energy laboratories (Argonne, Brookhaven, Oak Ridge, and Pacific Northwest) and four additional members to be appointed by the President.

Because the membership and responsibilities of the two groups are so similar, it is possible that the interagency Committee may evolve into the Task Force. A transition will avoid duplication of effort and will allow the Acid Precipitation Task Force to build upon the assessment program developed by the Acid Rain Coordination Committee.

NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS

To date, the criteria pollutants have been the major focus of air pollution control efforts. But increasingly more attention will be devoted to control of hazardous air pollutants under Section 112 of the Clean Air Act.

Seven substances have been listed as hazardous under Section 112 —asbestos, mercury, beryllium, vinyl chloride, benzene, radionuclides, and arsenic. EPA has issued proposed or final emissions standards for a number of sources of these pollutants. They are listed in Table 4–8. Other air pollutants from stationary sources are under consideration for designation as hazardous under Section 112. They include polycyclic organic matter, cadmium, ethylene dichloride, perchloroethylene, acrylonitrile, methylene chloride, methyl chloroform, toluene, and trichloroethylene.

Table 4–8

Sources of Hazardous Pollutants with Established Emissions Standards

Pollutant	Source
Asbestos	Asbestos mills, road surfacing with asbestos tailings, manufacturers of asbestos-containing products (fireproofing, etc.), demolition of old buildings, spray insulation
Beryllium	Extraction plants, ceramic manufacturers, foundries, incinerators, rocket motor manufacturing operations
Mercury	Ore processing, chlor-alkalai manufacturing, sludge dryers and incinerators
Vinyl chloride	Ethylene dichloride manufacturers, vinyl chloride manufacturers, polyvinyl chloride manufacturers

Source: Information provided by the U.S. Environmental Protection Agency.

In October 1979, EPA proposed a general methodology which it intends to use to identify, assess, and regulate suspected carcinogens that are emitted from stationary sources.[25]

Under the proposed policy, EPA will evaluate information in order to identify those substances, including radioactive materials, which should be considered for regulation under the Clean Air Act as airborne carcinogens. Any air pollutant determined to present a significant carcinogenic risk to human health as a result of emissions from one or more categories of stationary sources will be listed under Section 112 as a hazardous air pollutant. Listing under Section 112 will be accompanied, when applicable, by the proposal of generic emissions standards for source categories producing or handling significant quantities of the substance. These standards would be intended to effect reasonable control of emissions rapidly while more detailed analyses are performed to establish priorities for further regulation, determine available control technology, and assess regulatory impacts.

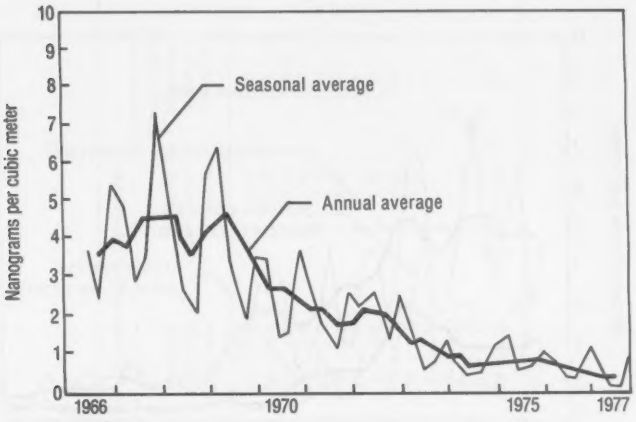
According to the proposed policy, final standards for source categories presenting significant risks to public health will, as a minimum, require such sources to use best available technology to reduce emissions. But if the risk remaining after the application of best available technology is determined to be unreasonable, additional measures like the closure of certain sources will be required. Determination of unreasonable residual risks will depend upon the magnitude of the risk, the benefits conferred by the substance or activity, the distribution of those benefits versus the distribution of risks, the availability of substitutes, the costs of further control of the substance or source categories, and proposed sites in the case of new sources. Standards will be reviewed at no more than 5-year intervals.

There is no comprehensive national network to monitor airborne carcinogens and other hazardous air pollutants, although one should be considered in view of the increasing attention given to hazardous air pollutants. However, EPA has monitored national trends in ambient concentrations of one particular hazardous pollutant, benzo(a)pyrene, B(a)P, at 26 urban and 3 non-urban sites.[26] Between 1966 and 1977, the average concentration fell from approximately 4 nanograms per cubic meter to approximately 0.5 ng/m^3, a reduction of about 88 percent. Both winter and summer concentrations declined. The quarterly composite average concentrations fluctuate because fossil fuel combustion and wood burning for home heating raise B(a)P emissions in the winter. Data for 1978 and 1979 are incomplete, but readings from selected sites confirm the 12-year trend. Of the 26 urban sites, 18 were in areas with coke ovens, a major source of B(a)P, and 8 were in urban areas where no coke ovens were located. The 3 non-urban sites were in National Parks.

Figure 4–11 shows the composite average concentration of B(a)P at the 26 urban sites. Figure 4–12 indicates that reduced concentrations have occurred in the urban areas with coke ovens as well as in those without coke ovens, but concentrations remained higher where coke ovens were located.

Figure 4-11

Composite Average Concentrations of Benzo(a)pyrene for 26 Urban Sites, 1966-77



Source: R.B. Faoro and J.A. Manning, "Trends in Benzo(a)pyrene, 1966-77," prepared for the U.S. Environmental Protection Agency, 1978, p. 6.

These substantial improvements in average ambient concentrations of B(a)P can be attributed to several factors: coal was used less frequently in utility and industrial boilers and for home heating; municipalities more vigorously enforced bans on open burning of leaves, solid wastes, and other materials, the incomplete combustion of which is a source of B(a)P; and B(a)P emissions from coke ovens were reduced.

It is not possible to generalize these conclusions to other hazardous air pollutants or even to other polycyclic organic materials. In fact, the downward trend in B(a)P concentrations could even be reversed if coal use increases in response to higher oil and natural gas prices. But it is clear that through 1977, concentrations of this hazardous air pollutant had declined substantially from earlier years.

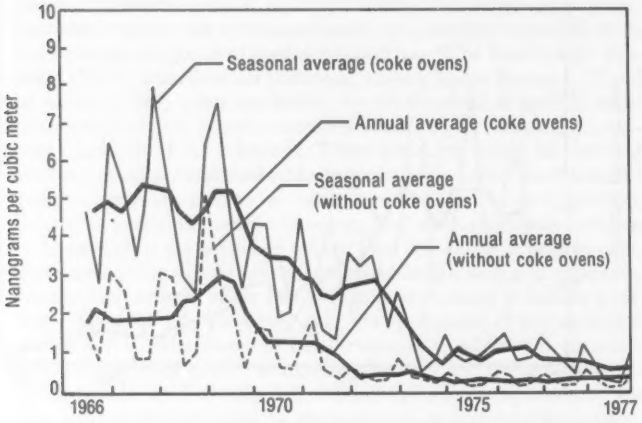
COMPLIANCE AND AIR QUALITY MANAGEMENT

As earlier parts of this chapter indicate, overall air quality seems to be improving steadily, whether measured by violations of the national standards or by ambient concentrations of the criteria pollutants. One reason could be that many sources of pollution are gradually coming into compliance with the Clean Air Act.

As of March 1980, there existed about 27,000 "major" stationary sources of air pollution—a major source is one with the potential to

Figure 4-12

Composite Average Concentrations of Benzo(a)pyrene with and without Coke Ovens for 26 Urban Sites, 1966-77



Source: R.B. Faoro and J.A. Manning, "Trends in Benzo(a)pyrene, 1966-77," prepared for the U.S. Environmental Protection Agency, 1978, p. 6.

emit more than 100 tons per year of any pollutant while operating at design capacity with no pollution controls.[27] Table 4–9 indicates the compliance status of nearly 6,000 major sources in 13 primary industries.

As the table indicates, compliance varies significantly among industries, although, overall, 90 percent of the 5,977 major sources in this sample are classified as being in compliance with air pollution emissions limitations. Of the 60 integrated iron and steel facilities, however, only 13 percent (8) are in compliance. Another 32 percent are in violation but are meeting a compliance schedule designed to bring them into compliance. More than one-half the sources, 53 percent, are in violation of SIP emissions limitations. Compliance is also low for the 28 primary smelters analyzed by EPA.

These data must be examined carefully in order not to convey an overly optimistic picture of progress in compliance for two reasons. First, not all the methods for determining compliance are equally rigorous. EPA and the states determine compliance with the emissions limitations established in a SIP by stack tests, in which actual emissions are measured and compared to the limitations imposed on each source; by site inspections, in which the state or EPA checks to see what control equipment is in place at the source, what kinds of

Table 4–9

Compliance Status of Major Air Pollution Sources, 1980

Industry	Number of total sources	Number and percentage ( ) in compliance with emissions limitations	Number and percentage ( ) in violation				
			Meeting compliance schedule	Violating emissions limitations	Violating compliance schedule	On compliance schedule, status unknown	Status unknown
Power plants (coal/oil)	700	559 (80)	54 (7)	67 (10)	3 (—)	0	17 (2)
Iron and steel (integrated)	60	8 (13)	19 (32)	32 (53)	1 (2)	0	0
Iron and steel (other)	144	102 (71)	15 (10)	24 (17)	3 (2)	0	0
Primary smelters	28	13 (46)	3 (11)	8 (25)	1 (4)	0	3 (11)
Pulp and paper	475	417 (87)	17 (4)	24 (5)	7 (1)	0	10 (2)
Municipal incinerators	72	60 (83)	2 (3)	7 (10)	3 (4)	0	0
Petroleum refineries	214	170 (79)	15 (7)	21 (10)	0	1	7 (3)
Aluminum reduction	49	37 (76)	2 (4)	8 (16)	2 (4)	0	0
Portland cement	200	176 (88)	3 (2)	18 (9)	1 (—)	0	2 (1)
Sulfuric acid	262	246 (94)	4 (2)	10 (4)	2 (—)	0	0
Phosphatic fertilizers	69	62 (90)	1 (—)	4 (6)	0	0	2 (3)
Coal cleaning	409	395 (97)	1 (—)	4 (1)	0	0	9 (2)
Grey iron	433	381 (88)	10 (2)	29 (7)	2 (—)	2	9 (2)
Asphalt concrete	2,862	2,752 (96)	14 (—)	39 (1)	3 (—)	0	54 (2)
Total	5,977	5,378 (90)	160 (3)	295 (5)	28 (—)	3	113 (2)

Source: Information provided by the U.S. Environmental Protection Agency.

fuels are being used, and other information on operations, but in which no actual emissions readings are taken; and by "certification," in which compliance is based on information sent to the state or to EPA *by the source* at the time that it commences operations and annually thereafter.

Although stack tests and inspections are preferable to certification in determining compliance, they are much more costly and consequently are used much less frequently. For example, of the 5,378 major sources found in compliance, 57 percent were determined on the basis of certification, 38 percent were based on inspections, and only 5 percent were based on emissions tests—the most reliable method of determining compliance. The compliance figures in Table 4–9, then, are not definitive evidence that compliance is as widespread as it may appear.

A second reason for caution in interpreting the compliance data is the nature of enforcement actions that have been taken against violators. Table 4–10 indicates the number and types of enforcement actions that EPA has taken over the last 3 years. EPA enforcement actions against stationary source violators have increased not only in frequency—having risen 17 percent between 1977 and 1979—but in seriousness as well. This observation follows from the number of civil and criminal actions in 1978 and 1979 compared to 1977. Notices of violations (which indicate an intention to take further action if violations continue) and administrative orders (which simply specifiy cleanup schedules for violators) are much less strong enforcement actions than initiation of c
The increase in stronger measures is in
amendments to the Clean Air Act in
EPA to eschew lengthy negotiations with long-time violators in favor of court proceedings.[28]

It should be noted that the states take many enforcement actions on their own. According to a recent report by the General Accounting Office, in 1977 the states took 15,646 enforcement actions, of

Table 4–10

Number of EPA Enforcement Actions, 1977–79

Type of Action	Fiscal year		
	1977	1978	1979
Notice of violation	381	480	444
Administrative order	259	87	209
Civil and criminal action	22	150	119
Total	662	717	772

Sources: For 1977, U.S. General Accounting Office, *Improvements Needed in Controlling Major Antipollution Sources*, CED–78–165 (Springfield, Va.: National Technical Information Service, 1979), p. 16; for 1978 and 1979, U.S. Environmental Protection Agency.

which 9,475 (61 percent) were notices of violations, 3,630 (23 percent) were administrative orders, and 2,541 (16 percent) were civil actions. Of the latter civil actions, 1,613 were taken by local air pollution agencies in California.[29]

STATE IMPLEMENTATION PLANS

The 1977 amendments to the Clean Air Act directed the states to prepare revised state implementation plans (SIPs) by July 1, 1979, that would indicate how air quality would be brought up to national standards in areas where violations continued.[30] The SO_2, TSP, and NO_2 standards must be met by 1982 and the CO and O_3 standards by 1987. States needing until 1987 to meet the CO and O_3 standards were required to institute a motor vehicle inspection and maintenance (I/M) program as a means of controlling emissions of these auto-related pollutants.

As of September 2, 1980, all 51 states or territories whose plans were due July 1, 1979, had officially submitted their SIPs; 40 were complete. Kansas, Missouri, Pennsylvania, Ohio, Indiana, Minnesota, Idaho, Tennessee, Arizona, Guam, and Nebraska had submitted partial plans. Hawaii's plan, which was not due until June 1980, had not been submitted.

EPA has taken final action on 17 of the completed plans. Three—Wyoming, Mississippi, and Arkansas—were approved. Thirteen were approved with conditions: Colorado, Georgia, South Carolina, Louisiana, Maine, Vermont, Delaware, New Jersey, Florida, North Carolina, New Hampshire, Oregon, and Virginia. South Dakota's plan was disapproved.

EPA gave the states until June 30, 1979, to establish adequate legal authority to carry out their I/M programs. The programs must be fully operational—having adopted and submitted to EPA requirements for mandatory inspection of motor vehicle pollution controls and repair of vehicles that fail—by the end of 1982 if centralized and by the end of 1981 if decentralized. If a state fails to develop an I/M program as required, EPA will regard its SIP as inadequate and apply sanctions. As of September 11, 1980, 27 of the 29 states where I/M programs are mandatory had the necessary legal authority to institute them. Kentucky and California did not, and EPA had initiated actions which could limit their federal funding for sewer and highway projects. Seven I/M programs were operating.

INDOOR AIR QUALITY

Air quality is generally taken to mean ambient conditions outdoors. But exposure to air pollutants indoors is just beginning to be analyzed and assessed.

There are several reasons for concern about indoor air quality. First, most people are indoors most of the time. Even moderate concentrations of pollutants encountered indoors, then, are potentially significant.

Second, as homeowners, landlords, and commercial and industrial establishments insulate their dwellings and buildings in response to rising energy prices, they may seal in not only warm or cool air but stale and possibly polluted air as well. Prior to major energy conservation efforts, the average home experienced approximately one air change per hour. But vigorous private conservation efforts, augmented by the Department of Energy's recent Residential Conservation Service program and its recent proposed Building Energy Performance Standards,[31] may reduce home ventilation to an average 0.2–0.3 air changes per hour. In that event, indoor air pollution may well become more serious.

Indoor pollutants which are of concern include several that are regulated outdoors under the National Ambient Air Quality Standards and others. Carbon monoxide and nitrogen dioxide are emitted from gas stoves and unvented space heaters, sometimes resulting in indoor pollution concentrations which may exceed national ambient (outdoor) standards. NO_2 and CO concentrations have been studied in an energy-efficient house maintained by Lawrence Berkeley Laboratory researchers in Walnut Creek, California.[32] Meals there are prepared with a gas stove and oven according to typical use patterns for U.S. families.

One in every 20 homes uses wood for home heating; however, care must be taken to avoid serious indoor air pollution (James MacKenzie).

The researchers found that 1-hour average concentrations of both NO_2 and CO are highest in the kitchen, although they also exceed outdoor levels in both the living room and bedroom. EPA's proposed new 1-hour outdoor CO standard (29 mg/m³ or 25 ppm) is not exceeded in any of the rooms in the study house. There is no 1-hour ambient standard for NO_2, but EPA has been considering a range of possible short-term standards. If a 1-hour ambient standard is established for NO_2 at a level below 440 $\mu g/m^3$, it would be exceeded at peak periods by indoor concentrations in the kitchen, living room, and bedroom of the study house.

Two other pollutants that may adversely affect indoor air quality are formaldehyde and radon gas. Perhaps best known as an embalming fluid, formaldehyde is a common ingredient in foam insulation, furniture, carpets, drapes, and other household items. Its largest use is as a component of resins used as bonding agents in plywood and particle board. Formaldehyde is also a byproduct of combustion processes (natural gas used in cooking and home heating, for example).

Formaldehyde can produce health effects ranging from acute nausea, eye irritation, and respiratory impairment to more serious longer-term effects like cancer. The Chemical Industry Institute of Toxicology has initiated a study on the effects of formaldehyde inhalation on rats and mice.[33] Although the study is not complete, the rats have shown a sharp increase in incidence of cancer of the lining of the nose and throat; the mice have developed no malignancies.

Several nations have proposed or adopted standards limiting formaldehyde concentrations in indoor air, as shown in Table 4–11. The Netherlands set a standard of 0.1 ppm in July 1978. Denmark, Sweden, and West Germany are also considering the establishment of indoor standards for formaldehyde. Studies conducted in Denmark, Sweden, West Germany, and the United States frequently found indoor formaldehyde levels in excess of 0.12 ppm, and in several cases it exceeded 3.0 ppm, the U.S. standard for workplace air set by the Occupational Safety and Health Administration. The studies showed that formaldehyde concentrations exceeded 0.12 ppm in a number of new residential buildings and mobile homes having fewer than 0.3 air changes per hour.

Formaldehyde levels have been measured by Lawrence Berkeley Laboratory researchers at several energy-efficient research houses. Data from a house in Mission Viejo, California, are shown in Table 4–12. As shown, when the house did not contain furniture, formaldehyde levels were below 120 $\mu g/m^3$; when furniture was added, formaldehyde levels almost tripled. A further increase was noted when the house was occupied, probably because of cooking with gas. When windows were opened to increase ventilation, formaldehyde levels dropped substantially. The Consumer Product Safety Commission recently designated formaldehyde and urea formaldehyde

Table 4–11

Recommended and Promulgated Formaldehyde Exposure Limits

Type of exposure	Country	Exposure limit (ppm)	Status
Outdoor ambient air	United States	0.1—Ceiling	R (AIHA)
	West Germany	0.025—Ceiling	P
	USSR	0.008—Ceiling	P
Indoor air	Denmark	0.12—Ceiling	R
	Netherlands	0.1—Ceiling	P
	Sweden	0.1–0.4—Ceiling	R
	West Germany	0.1—Ceiling	R
Occupational air	United States	3.0—TWA •	P (OSHA)
		2.0—Ceiling	P (ACGIH)
		1.0—Ceiling	R (NIOSH)
	Denmark	1.0—TWA	P
	West Germany	1.0—TWA	P
	East Germany	1.7—TWA	P
	Sweden	2.5—Ceiling	P
	Czechoslovakia	1.7—TWA	P
	USSR	0.4—Ceiling	P
	Bulgaria	4.0—Ceiling	P
	Finland	5.0—Ceiling	P
	Great Britain	10.0—Ceiling	P
	Hungary	0.8—Ceiling	P
	Italy	4.7—Ceiling	P
	Poland	4.7—Ceiling	P
	Rumania	2.5—Ceiling	P
	Japan	5.0—Ceiling	P

R = Recommended.
P = Promulgated.
TWA = 8-hr time-weighted average.
AIHA = American Industrial Hygiene Association.
OSHA = Occupational Safety and Health Administration.
ACGIH = American Conference of Governmental and Industrial Hygienists.
NIOSH = National Institute for Occupational Safety and Health.

Source: National Academy of Sciences, Committee on Toxicology, *Formaldehyde —An Assessment of Its Health Effects* (Washington, D.C., 1980), p. 28.

foam insulation as priority projects, in part because of nearly 500 complaints about health-related problems.[84]

Much of the natural background radiation to which the general population is exposed comes from the decay of Radium-226 which produces radon gas and other products. Because radium is a trace element in most rock and soil, radon can be produced indoors by a wide variety of substances, from building materials such as concrete or brick to the soil under building foundations. Tap water taken from wells or underground springs may be an additional source. Tests indicate that indoor concentrations of radon and its decay products are often higher than those outdoors.

High indoor concentrations of radon are of concern because of the potential carcinogenicity of its decay products. In fact, the EPA Office of Radiation Programs has estimated that current exposures

Table 4–12

Indoor/Outdoor Formaldehyde Concentrations Measured at an Energy-Efficient Residence, 1979

Condition	Number of measurements	Sampling time (hrs)	Formaldehyde (μg/m³) [a]
Unoccupied without furniture	3	12	80 [b]
Unoccupied with furniture	3	24	223 [b]
Occupied day [c]	9	12	261 [b]
Occupied night [d]	9	12	140 [e]

[a] Determined using pararosaniline method (120 μg/m³ = 100 ppb). All outside concentrations = 10 μg/m³.
[b] Accurate to within 10 percent.
[c] Air exchange rate = 0.4 ach.
[d] Windows open part of time; air exchange rate significantly greater than 0.4 ach and variable.
[e] Accurate to within 30 percent.

Source: C. D. Hollowell et al., "Building Ventilation and Indoor Air Quality," U.S. Department of Energy, Washington, D.C., 1980, p. 7.

to radon gas could account for as much as 10 percent of all deaths from lung cancer in the United States.[35] Such estimates must be carefully checked, but it is clear that additional research on radon, formaldehyde, and other indoor pollutants is badly needed.

An additional indoor air pollution problem involves suspended particulate concentrations in the home, at the workplace, and in other enclosed environments—concentrations that can rival those outdoors. Because suspended particulate matter is the criteria pollutant most consistently linked to elevated death rates in large-scale epidemiological studies and because of the time spent indoors, the potential health effects are great.

A recent study measured concentrations of respirable suspended particulates (RSPs)—those less than 15 microns in diameter—in indoor environments in both the presence and absence of cigarette smoking.[36] In indoor environments where no smoking was taking place, RSP levels averaged 40 $\mu g/m^3$ and were comparable to nearby outdoor concentrations.

By contrast, respirable suspended particulate levels in about 20 indoor environments with varying amounts of cigarette smoking taking place were generally markedly higher. Levels ranged from 30 $\mu g/m^3$ to 697 $\mu g/m^3$, depending on average room occupancy, sampling time, and density of active smokers. In six situations, the RSP concentration exceeded the 24-hour average national ambient air quality standard for total suspended particulates (260 $\mu g/m^3$), and in almost every situation, concentrations exceeded the NAAQS for average annual TSP concentrations. Levels of RSP appeared to vary directly with active smoker density. In view of recent evidence linking respiratory impairment in nonsmokers to occupational exposures to cigarette smoke,[37] these findings merit serious consideration.

Although indoor air quality is obviously of concern, the responsibilities of federal agencies in this area are unclear. The Occupational Safety and Health Administration has rules governing workplace exposures to some substances, but these standards would not apply to the non-occupational settings discussed above. It has not been determined whether EPA authority under the Clean Air Act extends to indoor exposures for pollutants for which the Agency has established ambient standards or emissions limits under Section 109 or 112 or for any other pollutants.

Methods for control of indoor pollution do exist. For example, indoor particulate levels can be controlled by coarse fiber filters in space conditioning systems (common in office buildings and institutions), by electrostatic precipitators, by outside venting of gas furnaces, and by activated charcoal or carbon absorbers.

A promising approach to improving indoor air quality is to use controlled mechanical ventilation through an air-to-air heat exchanger. A heat exchanger transfers heat from the outgoing warm air to incoming cold air (or vice versa during the air conditioning season). It allows increased ventilation at a much lower heating or cooling cost than a simple exhaust fan.

REFERENCES

1. Clean Air Act, § 109(d), 42 U.S.C. § 7409(d) (1979).
2. 45 Fed. Reg. 55066, 55071–55072 (1980).
3. "Acid Rain Research Program—Memorandum from the President," *Weekly Compilation of Presidential Documents* 15(31):1389 (1979).
4. See Federal Interagency Task Force on Air Quality Indicators, *A Recommended Air Pollution Index* (Washington, D.C.: U.S. Government Printing Office, 1976).
5. See Comptroller General of the United States, *Air Quality: Do We Really Know What It Is?* CED–79–84 (Washington, D.C.: U.S. Government Printing Office, 1979).
6. 44 Fed. Reg. 27571 (1979).
7. In a recent analysis of 1979 data, EPA found a slight decrease between 1978 and 1979, offsetting the slight upward trend from 1977 to 1978. See U.S. Environmental Protection Agency, "National Ozone Monitoring, Status and Trends, 1979" (review draft, July 1980).
8. U.S. Environmental Protection Agency, "Trends in the Quality of the Nation's Air: A Report to the People," EPA–16–9 (draft, 1980).
9. *Ibid.*
10. *Ibid.*
11. Richard Stoiber, Stanley Williams, and Lawrence Malinconico, "Mount St. Helens, Washington, 1980 Volcanic Eruption: Magmatic Gas Component during the First 16 Days," *Science* 208:1258–59 (1980).
12. U.S. Environmental Protection Agency, Committee on Monitoring and Information Management, "Pilot Assessment of Ambient Conditions" (February 1980).
13. Clean Air Act, § 109(d), 42 U.S.C. § 7409(d) (1979).
14. 45 Fed. Reg. 55066–83 (1980).
15. Clean Air Act, § 109(c), 42 U.S.C. § 7409(c) (1979).
16. U.S. Environmental Protection Agency, "Air Quality Criteria for Particulate Matter and Sulfur Oxides" (external review draft 1, April 1980).

17. *Ibid.*
18. *Ibid.*
19. Clean Air Act, § 107(a), 42 U.S.C. § 7407(a) (1979).
20. Id. at § 126(c), 42 U.S.C. § 7426(c) (1979).
21. Clean Air Act, § 123(c), 42 U.S.C. § 7423(c) (1979).
22. 44 Fed. Reg. 2608 (1979).
23. "Environmental Priorities and Programs—Message to the Congress," *Weekly Compilation of Presidential Documents* 15(31):1353 (1979).
24. Energy Security Act of 1980, Pub. L. 96–294, 94 Stat. 611 (1980).
25. 44 Fed. Reg. 58643 (1979).
26. Robert Fadro and Justice Manning, "Trends in Benzo(a)Pyrene, 1966–1977," prepared for the U.S. Environmental Protection Agency (Washington, D.C., 1978).
27. As a result of *Alabama Power Company et al.* v. *Costle*, — F.2d —, 13 ERC 1993 (D.C. Cir. 1979), a major source will be defined in the future as one with the potential to emit 100 tons per year of any pollutant while operating at design capacity (i.e., *with* pollution controls).
28. Clean Air Act, § 120, 42 U.S.C. § 7420 (1979).
29. Comptroller General of the United States, *Improvements Needed in Controlling Major Antipollution Sources*, CED–78–165 (Washington, D.C.: U.S. Government Printing Office, 1979).
30. Clean Air Act, § 110(a)(3), 42 U.S.C. § 7410(a)(3)(1979).
31. 44 Fed. Reg. 68120 (1979).
32. C.D. Hollowell et al., "Building Ventilation and Indoor Air Quality," LBL–10391, prepared for the U.S. Department of Energy (Washington, D.C., 1980), p. 7.
33. James A. Swenberg et al., "Induction of Squamous Cell Carcinomas of the Rat Nasal Cavity by Inhalation Exposure to Formaldehyde Vapor," *Cancer Research* 40:3398–3402 (1980).
34. National Academy of Sciences, Committee on Toxicology, "Formaldehyde: An Assessment of Its Effects" (Washington, D.C., 1980).
35. Information provided by the U.S. Environmental Protection Agency.
36. James Repace and Alfred Lowry, "Indoor Air Pollution, Tobacco Smoke, and Public Health," *Science* 208:464 (1980).
37. J.R. White and H.F. Froeb, "Small-Airways Dysfunction in Nonsmokers Chronically Exposed to Tobacco Smoke," *New England Journal of Medicine* 302:720 (1980).

Chapter 5

TOXIC SUBSTANCES AND ENVIRONMENTAL HEALTH

Chemicals are invaluable to society, and most are believed relatively safe under normal conditions of use. But there are many chemicals whose environmental and health effects are unknown and some that have been proved harmful. Humans are exposed to toxic substances in a variety of ways—through the air that they breathe, the water that they drink, the food that they eat, and the drugs, cosmetics, and other consumer products that they use. The workplace, because of the concentration and duration of exposure to toxic chemicals, can be one of the most serious sources of exposure to them.

The range of adverse human health effects of exposure to chemicals and other toxic substances is very broad. High level exposures to some substances for even a short time may produce acute, though often temporary, effects such as rashes, burns, or poisoning. Prolonged exposure to low doses can cause chronic lung diseases, cancers, sterility, and other problems. Although not quantifiable with certainty, there is growing evidence that toxic substances in the environment can cause reproductive problems, including miscarriages and birth defects.

In recent years, the possibility that toxic substances in the environment can cause cancer has been the focus of intense public and government concern. Cancer is the only major cause of death whose incidence has continued to rise since 1900. Smoking is undoubtedly part of the cause, but there is evidence that other factors, perhaps including increased public exposure to synthetic organic chemicals, may also be contributing. Yet cancers are not the only problem. Other effects of chronic low level exposure to toxic subtances can be equally damaging. Two of these effects—lung disease and reproductive problems—are discussed in this chapter.

In considering the health effects of toxic substances, the government must give attention to substances which are common and therefore to which many, many people are exposed. Three such substances are lead, caffeine, and—increasingly—diesel exhaust. Although some of the chronic effects of exposure to lead have been

known for years, recent evidence suggests that doses even lower than those previously thought to injure health have both physiological and psychological effects.

Caffeine, a major component of coffee, cola, and chocolate, has been shown in laboratory tests to cause chromosomal damage. Implications for the continued use of caffeine are far from clear, but a recent report prepared for the Food and Drug Administration concludes that it is "inappropriate to include caffeine among the substances generally recognized as safe." [1]

A substantial increase is expected in the number of light-duty diesel-powered cars and light trucks produced in the United States over the next several years. Although highly desirable for their fuel efficiency, diesels may pose significant health and environmental risks. Whether action to control diesel emissions is warranted depends upon the results of health effects studies to be completed in 1980.

Another—and as yet poorly quantified—source of public exposure to toxic chemicals is the dumping of hazardous wastes. During the past year, several serious incidents of environmental contamination and adverse health effects from hazardous waste disposal were discovered, including those in Legler, New Jersey; Baxter County, Arkansas; and Gartiot County, Michigan. This year the Congress passed "superfund" legislation, giving the Environmental Protection Agency (EPA) authority and funds to clean up spills of hazardous substances and abandoned waste sites systematically. EPA issued regulations last February and May implementing Subtitle C of the Resource Conservation and Recovery Act, which will eventually provide cradle-to-grave control of hazardous wastes. Perhaps because of these regulations a Colorado company sought to export hazardous wastes to Sierra Leone and other less developed countries early in 1980. The proposed project was canceled when it became public knowledge, but the export of hazardous wastes may be a growing problem.

Controlling toxic substances in the environment is presenting a new challenge to the legal and regulatory system of the nation. With growing evidence of the human effects of some toxic substances, the number of lawsuits and other efforts to obtain compensation by injured parties appears to be rising. Compensation of victims could provide a means of inducing action to prevent pollution and thereby to supplement regulation. To date, however, most programs appear to have had little deterrent effect.

Implementation of the toxic substance control laws, such as the Toxic Substance Control Act (TSCA) and the Federal Insecticide, Fungicide and Rodenticide Act, has raised serious policy issues concerning trade secrets obtained by federal agencies. The identity of a chemical or its effects on health and the environment are sometimes considered trade secrets and therefore confidential; however, it is frequently important for the public to have this information.

Implementation of TSCA has also raised numerous questions concerning testing of the thousands of chemicals in commercial use,

including who should test them, when they should be tested, and for what effects they should be tested. While these and similar questions are debated, implementation is slow. In June 1980, the Toxic Substances Strategy Committee submitted its final report, *Toxic Chemicals and Public Protection,*[2] to the President, who had established the Committee in 1977 to assess federal research and regulation of toxic substances in the environment. The Committee is chaired by the Council on Environmental Quality and is composed of 18 members representing all the federal agencies with major research, regulatory, and other responsibilities for toxic substances control.

The Committee concluded that the basic approach of the more than two dozen statutes that regulate toxic chemicals is sound. However, it recommended new legislation in four areas:

- A means must be established to provide for cleanup of abandoned and inactive hazardous waste sites like Love Canal, in Niagara Falls, New York.
- Federal authority over cosmetics should be strengthened.
- Barriers to the ability of federal agencies to share confidential and trade secret data with other government entities and the public should be eliminated.
- The government should be authorized to provide funding when necessary to expand public participation in toxic substance regulatory proceedings.

The Committee also called for a governmentwide data network to ensure ready access to all types of information on the many thousands of chemical substances in commerce today, information now stored in some 220 separate data systems. It recommended that the government work to improve public understanding of animal tests and protocols used in assessing the cancer risks of chemicals, including the point that administration of large doses to laboratory animals is widely accepted by scientists as a valid method for identifying carcinogenic substances but that methods do not yet exist for determining "safe" levels of human exposures.

HEALTH EFFECTS OF TOXIC CHEMICALS

CANCER TRENDS

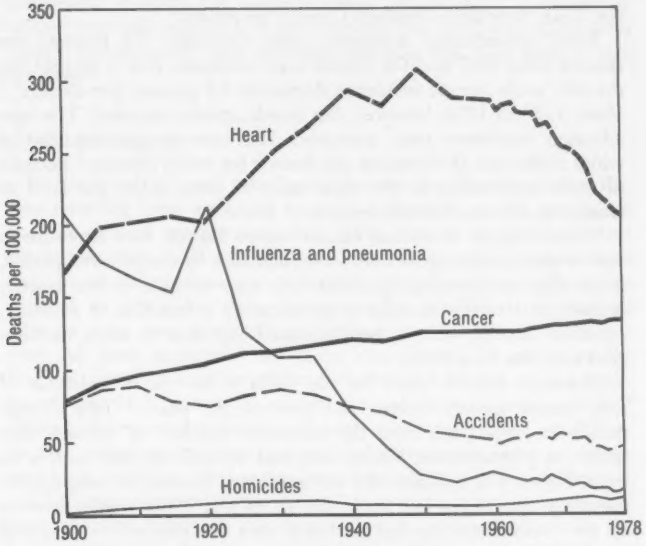
Cancers are second only to heart disease as a cause of death in the United States. As shown in Figure 5–1, overall, age-adjusted * death rates from cancers increased steadily from 1910 to 1940 (24 percent for the 30-year interval, 7.4 percent per decade).** Between

* Age adjustment is a statistical technique for correcting (cancer) rates when comparing different populations with different age profiles.

** Rates are compounded.

Figure 5-1

Age-Adjusted Rates for Major Causes of Death, 1900-1978



Source: M.A. Schneiderman, National Cancer Institute, 1979, based on U.S. Department of Health, Education, and Welfare Vital Statistics reports.

1930 and 1970, cancer mortality continued to increase, but at a markedly slower rate (8 percent, about 2.6 percent per decade).[3]

Cancer mortality increased at about this rate in the 1960s. Male and female cancer rates combined increased 3 percent from 1960 to 1970.[4] The most recent data, for the 7 years 1969–76, show that per decade, mortality rose 5.6 percent,[5] which may indicate an acceleration in cancer rates.

Understanding the meaning of these trends in cancer statistics requires examination of additional data. It is important to recognize that exposure to some chemicals and other environmental factors are responsible for the majority of human cancers. These factors include smoking, chemical carcinogens, radioactivity, sunlight, diet, and, possibly, viruses.

Exposure to a carcinogen does not immediately cause a cancer; usually 5–40 years pass before a tumor is diagnosed.

Incidence rates reflect diagnosis of a malignancy; mortality rates reflect death from the disease. Incidence data are especially important because they provide more and earlier information about

cancer causes than do mortality rates. Incidence rates may function as a kind of leading indicator of the state of human exposures to carcinogens. Between 1969 and 1976, the latest period examined, cancer *incidence* data seem to parallel the recent rise in mortality. These potentially serious developments were carefully analyzed in the Toxic Substances Strategy Committee report.[6]

Total age-adjusted incidence rates decreased 1.8 percent per decade from 1947 to 1970 (white male incidence rose 4 percent per decade; white female incidence decreased 7.6 percent per decade).[7] From 1969 to 1976, however, the trends appear reversed. The age-adjusted incidence rates increased 12.7 percent per decade for white males and 18.4 percent per decade for white females.[8] Because of some uncertainty in the data bases of these rates, the level of change in incidence trends remains in doubt.

These changes in overall cancer trends suggest that exposure to one or more carcinogens may have increased in the postwar period, a rise that is becoming apparent only now because of the latency period. Part of the increase is undoubtedly a function of smoking, especially among women, but increased exposure to other carcinogens may also be a factor.

The most notable trend for the 1970s is the rise in incidence of lung cancer among women (8.6 percent per year).[9] This change results in large part from the increased number of women who smoke, a phenomenon which occurred several decades earlier in men. Figure 5–2 indicates the extraordinary increase in lung cancer mortality that began in men in the 1930s and 1940s and in women in the 1960s. Smoking has probably also contributed to increased mortality from pancreatic, bladder, kidney, and esophageal cancers.

Although a smaller percentage of men smoke cigarettes today than in earlier decades (and cigarettes contain less tars), men experienced an increased incidence of lung cancer of 1.4 percent per year and increased mortality of 2.6 percent per year in the 1970s.[10] The time lag between smoking and the discovery of a lung cancer only partially explains the fact that men are still showing increased lung cancer incidence and mortality rates even though a smaller percentage smoke and many cigarettes are less hazardous. Lung cancer incidence also continues to rise among nonsmokers, presumably because of exposure to other carcinogens,[11] including the smoke from others' cigarettes. Lung cancer mortality among nonsmokers rose almost 100 percent between 1958 and 1968,[12] and an analysis of 1970–76 incidence data suggests that lung cancer in men who do not smoke increased 37–65 percent, depending on several variables.[13]

It is not entirely clear what causes other than smoking may be responsible for recent cancer trends. One that has been suggested is the synthetic organic chemicals manufactured and used on an increasingly large scale since World War II,[14] as shown in Figure 5–3. A number of them are carcinogenic.[15]

Workers exposed to high concentrations of carcinogenic chemicals may be at considerably greater risk of cancer than is the general

public. Many of these chemicals also enter the environment as products or wastes, placing many millions of people at some presumably smaller individual risk.

Whether the increasing use of carcinogenic chemicals during the last several decades has brought about an increased incidence of cancer that will continue to rise through the next several decades cannot be answered with certainty because the data base is not adequate.

LUNG DISEASES

In the minds of most people, cancers are *the* life-threatening disease resulting from exposure to toxic substances in the workplace and the general environment. But other diseases of environmental origin also pose serious health problems. Occupational exposure to dusts is an illustration. An estimated several million workers are exposed to free silica dust. A comparable number is exposed to asbestos dust, and hundreds of thousands are exposed to cotton dust. All these exposures may cause lung disease. A survey by the National Institute for Occupational Safety and Health, for example, found that 12.5 percent of miners suffered from pneumoconiosis.[16] Other airborne contaminants can cause other pulmonary conditions. In fact, airborne contaminants and pollutants may cause or aggravate lung conditions that range from mild colds to fatal emphysema.

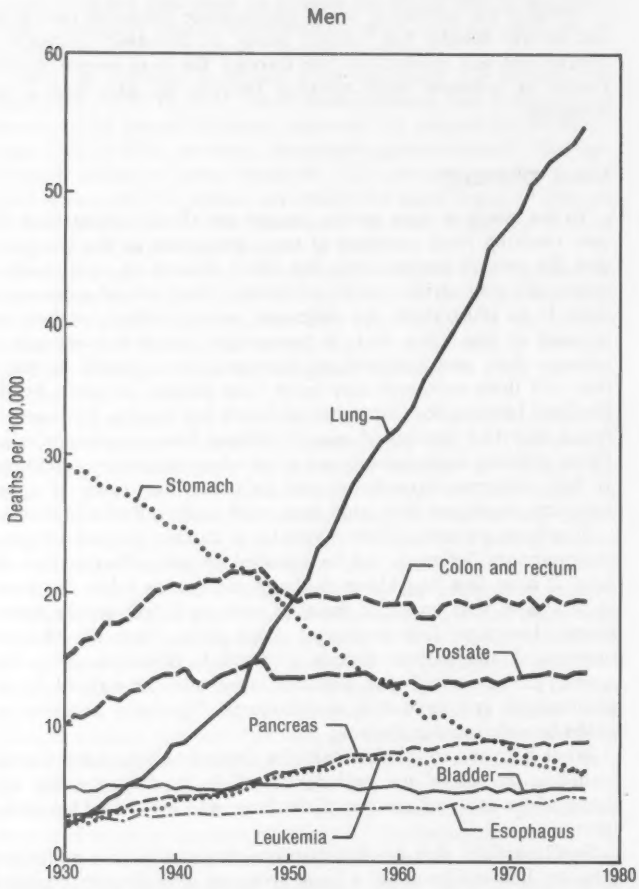
The lungs are particularly vulnerable to damage by environmental contaminants. Before air can be absorbed by tissues deep within the lung, it must first flow along the large conducting tubes, the bronchial tree of that organ. It flows to very small balloon-like spaces where absorption (gas exchange) takes place. Here the blood is oxygenated and carbon dioxide eliminated. However, air is frequently contaminated with particles, some of them natural to the environment and some of them introduced. They may be deposited in the bronchus and in the lung.

What happens to inhaled particles depends upon many factors, including the size, shape, and density of the particle, the size and shape of the sacs and airways of the lung, and individual breathing patterns.

Small particles that are less than one-thousandth of a millimeter long are believed to cause a large group of lung diseases classified under the general term pneumoconiosis, literally, "dust in the lungs." Some of these diseases are known by the workplaces where they are produced—"black lung," a disease prevalent in coal workers; "brown lung," a disease of cotton textile workers; asbestosis, a disease of workers exposed to asbestos; and silicosis, a disease of workers exposed to silica-containing dusts (sand blasters, miners, glass and pottery makers, construction trade workers, and others). Dust from iron ore, graphite, aluminum, beryllium, and tungsten carbide also may lead to pneumoconiosis.

Figure 5-2

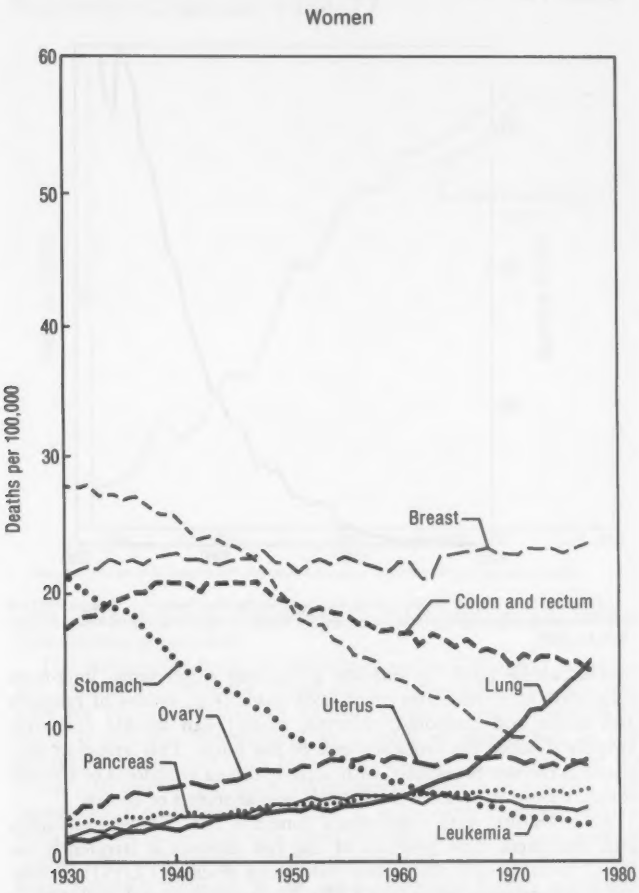
Age-Adjusted Cancer Death Rates, 1930–77



Symptoms of pneumoconiosis include shortness of breath and cough, and the effects are often profound. Pneumoconiosis generally results in the scarring or development of lesions on the small air sacs, resulting in their loss of ability to enlarge and thus to exchange gases. Pneumoconiosis may progress even after exposure to dust ceases. The disease is frequently incapacitating, with no known specific treatment. It may be fatal.

Figure 5-2 (continued)

Age-Adjusted Cancer Death Rates, 1930-77

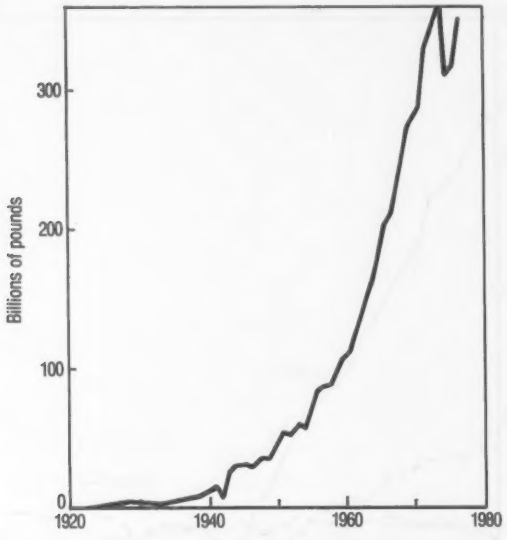


Source: Based on U.S. National Center for Health Statistics and U.S. Bureau of the Census data.

Another important and prevalent disease of the small air sacs of the lungs which may be aggravated or caused by exposure to pollutants is emphysema. This disease is characterized by enlargement of the air spaces of the lung as a result of destruction of the membranous walls between them. The disease results in severe, chronic, and often incapacitating shortness of breath. There is no known cure,

Figure 5-3

Annual Production of Synthetic Organic Chemicals, 1920-78



Source: D.L. Davis and B.H. Magee, "Cancer and Industrial Chemical Production," *Science* 206:1356 (1979), reprinted with permission of *Science* (copyright © American Association for the Advancement of Science, 1980).

and it can be fatal. In addition to causing emphysema, long-term inhalation of particulates or of toxic gases (e.g., oxides of nitrogen and sulfur and ammonia, chlorine, ozone) can irritate and irreversibly damage the bronchial tree of the lungs. This irritation may result in chronic bronchitis, with accompanying symptoms of chronic cough, wheezing, sputum production, and shortness of breath.

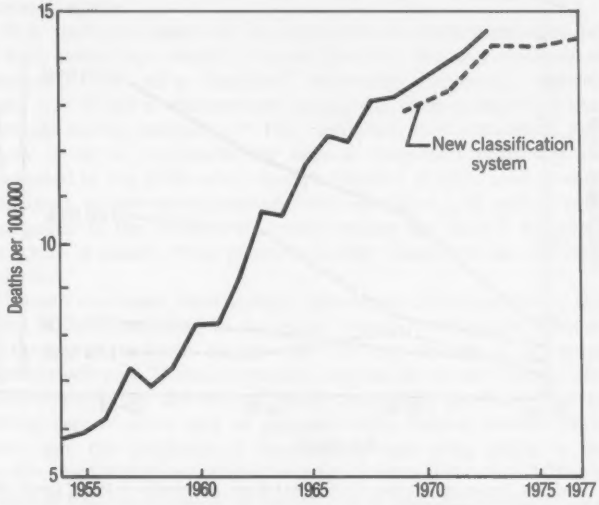
An individual with emphysema generally has chronic bronchitis, and vice versa. The complex of the two diseases is frequently referred to as chronic obstructive pulmonary disease (COPD). Smoking is the primary cause of COPD, but environmental pollution is also a factor.

There was a 10-fold increase among men in deaths due to COPD between 1950 and 1963. The number of deaths from emphysema, bronchitis, and asthma continued to increase through 1977 (as shown in Figure 5–4). Mortality from emphysema, together with chronic bronchitis, may exceed that from lung cancer.[17]

A 1966 study suggested that smoking is the most frequent cause of emphysema and related respiratory diseases.[18] In this study, there

Figure 5-4

Age-Adjusted Death Rates for Chronic Obstructive Pulmonary Diseases, 1954-77



Source: Based on U.S. Department of Health, Education, and Welfare Vital Statistics reports.

were 10–14 times more deaths from COPD among men who smoked than among nonsmokers.

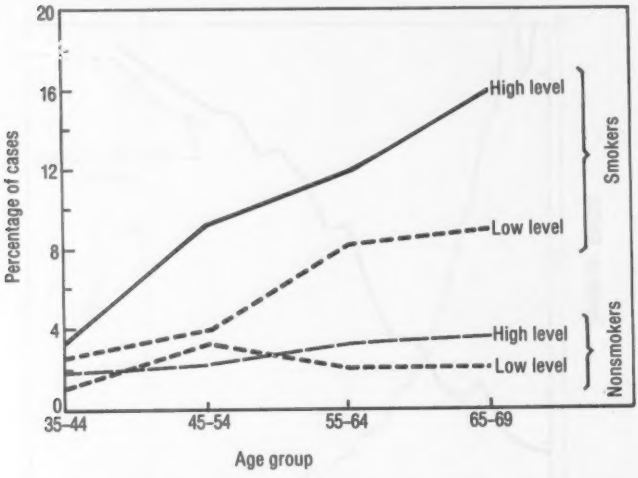
The relationship between individuals with COPD and air pollution remains controversial. Conducting studies with adequate controls for important variables such as smoking and socioeconomic status is difficult. Nevertheless, in a study of nonsmokers in two geographic areas, one with high air pollution (St. Louis) and the other with low air pollution (Winnipeg), subjects in the city with higher pollution showed four times as many cases of severe emphysema as those in the city with lower air pollution.[19] Another study of 10,000 men and women, both smokers and nonsmokers, suggests that, although smoking is the most important factor in causing emphysema, atmospheric pollution may aggravate the condition.[20] For older men and women, poor air significantly increased the prevalence of chronic bronchitis and emphysema, as shown in Figure 5–5.

REPRODUCTIVE EFFECTS

Much remains to be learned about the relation of reproductive disorders and environmental exposure to toxic substances. A growing

Figure 5-5

Relationship of Air Pollution Levels to Prevalence of Chronic Obstructive Pulmonary Disease by Age



Source: P.M. Lambert and D.D. Reid, "Smoking, Air Pollution, and Bronchitis in Britain," *Lancet* 1:856 (1970), reprinted with permission.

body of scientific evidence suggests that environmental exposures to smoking, alcohol, and other chemicals can affect the ability to conceive, by causing infertility in both males and females; the viability of the fetus, by causing spontaneous abortions, miscarriages, and stillbirths; and the health of the infant, by causing low birth weight or birth defects. Exposure to toxic substances can also affect heredity by acting directly on ova and sperm, creating defects which may be passed on for generations.

Problems exist for men--for whom exposure can cause lower sperm counts, malformed sperm, and genetic damage—as well as for women—for whom exposure can cause sterility. In addition, exposure can damage the human fetus. Controversy has arisen over such problems in the workplace, in particular whether to remove women from workplaces where substances could adversely affect pregnancy.

Approximately 7 percent of the babies born in the United States have major or minor congenital malformations.[21] Estimates of the number of spontaneous abortions caused by defective fetal development, stillbirths, and infant death vary widely, but most authorities believe that the rate is at least 20 percent.[22] The major reason for uncertainty in the estimate is that most spontaneous abortions occur

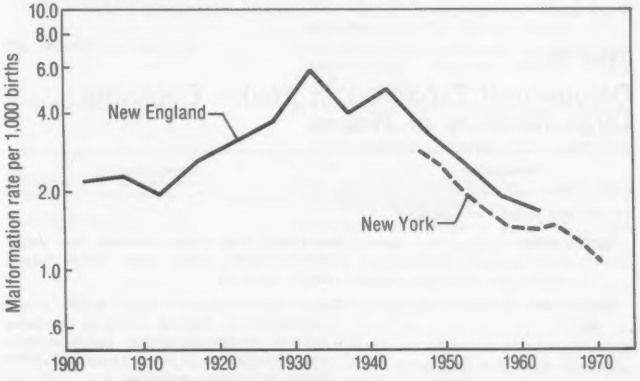
prior to the fourth week of pregnancy and are thus generally undetected. The causes of the great majority of malformations are unknown, although some epidemiologists strongly suspect, on the basis of studies, that most are environmentally caused[23]—that is, they are caused by alcohol, cigarette smoke, toxic chemicals, or other external agents.

Both medical concern for and progress on environmental causes of birth defects are relatively recent. In 1969, the near epidemic in European babies of a "seal-limb" deformity (flipper-like appendages) was linked to the mothers' taking the sleep-aiding drug thalidomide during pregnancy.[24] The realization that a synthetic substance could be responsible for adverse pregnancy outcomes was reinforced in the 1970s when diethylstilbestrol (DES), used in early pregnancy to prevent miscarriage, was associated with genital malformations in the children of women taking the drug.[25] Increased incidence of cancer of the genitalia in their daughters has also been observed.

Down's syndrome, anencephaly (nonclosure of the cranium), and spina bifida (nonclosure of the spinal column)—congenital diseases of the central nervous system—are the best studied of abnormal birth pathologies. There are genetic components to each disease. But these diseases may also cluster among genetically unrelated families during certain times and in geographically defined locales. Forty years ago, the incidence of anencephaly and spina bifida in the northeastern states was at least four times what it is today.[26] It continues to decline, as shown in Figure 5–6. It has been suggested that

Figure 5-6

Anencephaly and Spina Bifida Incidence in the Northeastern States, 1900–1970



Source: D.T. Janerich, "Epidemic Waves in the Prevalence of Anencephaly and Spina Bifida in New York State," *Teratology* 8:253 (1973) (copyright © 1973 by the Wistar Institute Press, Philadelphia).

this trend is best explained by environmental factors, which remain unidentified.[27] Although it might well be that, even under conditions of "ideal" environmental exposure, the incidence of these diseases would not be zero, observed variations with geography and time suggest external causes as well.

Recent epidemiological studies with complex synthetic fat-soluble organic compounds which are retained for extended periods in the human body indicate that adverse pregnancy outcomes can result from such exposure. Exposure of pregnant women to polychlorinated biphenyls (PCBs) was found to produce low birth weights and darkening of the babies' skin.[28] Polybrominated biphenyls (PBBs), dioxin, Mirex, and Kepone also produced adverse effects on infants.

Studies of lead, mercury, and aluminum indicate that these metals, too, may affect pregnancy outcome. An increased incidence of abortion and stillbirths among female workers exposed to high lead concentrations has long been recognized.[29]

The workplace is a significant source of exposure to agents that may adversely affect pregnancy. Table 5–1 lists occupations in which the percentage of women employees is high. Some of the substances to which they are exposed are known to affect female reproductive integrity adversely; others may have similar effects. Epidemiological studies have shown that a number of these chemicals may also affect male reproductive integrity. Further, abnormal sperm movement and structure, changes in male hormonal levels, depressed sperm counts, and abnormal composition of seminal fluid have been produced by toxic substances in the workplace. Among the environmental agents known to affect male reproduction are lead, zinc, cadmium, dibromochloropropane (DBCP), vinyl chloride, anesthetic gases, chloroprene, a number of hydrocarbons and polycyclic hydrocarbons, including several found in cigarette smoke, halogenated hydrocarbons, and drugs and alcohol, shown in Table 5–2.

Table 5–1

Occupational Exposures in Trades Employing Large Numbers of Women

Occupation	Exposure
Textile and related occupations	
Textile workers	Raw cotton dust, noise, synthetic fiber dusts, formaldehyde, heat, dyes, flame retardants, asbestos
Sewers and stitchers, upholsterers	Cotton and synthetic fiber dusts, noise, formaldehyde, organic solvents, benzene, toluene, trichloroethylene, perchloroethylene, chloroprene, styrene, carbon disulfide, flame retardants, asbestos
Hospital and health personnel	

Table 5–1 (continued)

Occupational Exposures in Trades Employing Large Numbers of Women

Occupational	Exposure
Registered nurses, aides, orderlies	Anesthetic gases, ethylene oxide, X-ray radiation, alcohol, infectious diseases, puncture wounds
Dental hygienists	X-ray radiation, mercury, ultrasonic noise, anesthetic gases
Laboratory workers (clinical and research)	Wide variety of toxic chemicals, including carcinogens, mutagens, and teratogens, X-ray radiation
Electronics assemblers	Lead, tin, antimony, trichloroethylene, methylene chloride, epoxy resins, methyl ethyl ketone
Hairdressers and cosmetologists	Hair spray resins (polyvinyl pyrrolidone), aerosol propellants (freons), halogenated hydrocarbons, hair dyes, solvents of nail polish, benzyl alcohol, ethyl alcohol, acetone
Cleaning personnel	
Launderers	Soaps, detergents, enzymes, heat, humidity, industrially contaminated clothing
Dry cleaners	Perchloroethylene, trichloroethylene, stoddard solvent (naphtha), benzene, industrially contaminated clothing
Photographic processors	Caustics, iron salts, mercuric chloride, bromides, iodides, pyrogallic acid, silver nitrate
Plastic fabricators	Acrylonitrile, phenol formaldehydes, urea formaldehydes, hexamethylenetetramine, acids, alkalies, peroxide, vinyl chloride, polystyrene, vinylidene chloride
Domestics	Solvents, hydrocarbons, soaps, detergents, bleaches, alkalies
Transportation personnel	Carbon monoxide, polynuclear aromatics, lead, and other combustion products of gasoline, vibration, physical stress
Sign painters and letterers	Lead oxide, lead chromate pigments, epichlorohydrin, titanium dioxide, trace metals, xylene, toluene
Clerical personnel	Physical stress, poor illumination, trichloroethylene, carbon tetrachloride and various other cleaners, asbestos in air conditioning
Opticians and lens grinders	Coal tar pitch volatiles, iron oxide, dust solvents, hydrocarbons
Printing personnel	Ink mists, 2-nitropropane, methanol, carbon tetrachloride, methylene chloride, lead, noise, hydrocarbon solvents, trichloroethylene, toluene, benzene, trace metals

Source: U.S. Department of Health, Education, and Welfare, National Institute for Occupational Safety and Health, *Guidelines on Pregnancy and Work* (Washington, D.C.: U.S. Government Printing Office, 1977), pp. 65–66.

Table 5–2

Effects of Environmental Chemicals and Drugs on Male Reproduction, from Human Studies

Agent	Type of study	Effect
Environmental chemical		
Anesthetic gases	Reproductive history	Increased incidence of congenital anomalies in offspring
Carbon disulfide	Semen analysis, reproductive history	Impotence, loss of libido
Chloroprene	Semen analysis, reproductive history	Decreased motility and sperm count, excess miscarriages in wives
Cigarette smoke	Semen analysis	Increase in abnormally shaped sperm
Dibromochloropropane	Semen analysis, reproductive history	Decreased sperm count, infertility
Hydrocarbons	Reproductive history	Increased incidence of childhood cancer with occupational hydrocarbon exposure of father
Kepone	Reproductive history	Decreased fertility in males
Lead	Semen analysis	Decreased motility and sperm count, increase in abnormally shaped sperm
Vinyl chloride	Reproductive questionnaire	Adverse pregnancy outcome in wives; excess fetal loss
Drug		
Alcohol	Autopsy	Testicular atrophy, azoospermia, testicular pathology
Amebicide	Clinical	Inhibited sperm motility, abnormal morphology, immature cells in ejaculate
Anticonvulsants	Survey of children of epileptics	Increased level of developmental disabilities
Antineoplastic agents	Clinical, epidemiologic	Reduced fertility
Clomiphene	Semen analysis	Decreased sperm count
Diamines	Testicular biopsy	Decreased spermatids, abnormal morphology of spermatids, azoospermia
Diethylstilbestrol	Clinical	Epididymal cysts, hypotrophic testes, capsular induration of testes, sperm abnormalities
Iodine	Clinical	Atrophy of testes
Oral contraceptives	Reproductive history, physical exam, blood analysis	Gynecomastia, decreased libido, infertility
Testosterone enanthate	Clinical	Sterility

Source: V. R. Hunt, *Work and the Health of Women* (Boca Raton, Fla.: CRC Press, Inc., 1979), pp. 158, 164, reprinted with permission (copyright © The Chemical Rubber Co., CRC Press, Inc.).

Data on birth defects are collected primarily by the Department of Health and Human Services' (HHS) Center for Disease Control in Atlanta in collaboration with the National Institute of Child Health and Human Development, the Commission on Professional and Hospital Activities in Ann Arbor, and the National Foundation-March of Dimes in Mount Vernon, New York. The National Center for Health Statistics (NCHS) in HHS, in conjunction with the Bureau of the Census, routinely records nationwide birth data, which include birth defects. But by and large the NCHS data are derived from birth certificates, which indicate only the more obvious defects seen at birth and miss the many malformations that become apparent only days or months later.

This network has compiled data on thousands of birth defects since 1970 and has detected some temporal and geographic changes and trends in the incidence of particular types of malformations. The problem remains, however, that the data that are collected and analyzed relate only to those abnormalities seen at live births. Epidemiological data on the larger proportion of conceptions that result in spontaneous abortion are not available. Nor can the incidence and causes of infertility be studied from this information.

There is currently intense disagreement over how best to minimize reproductive hazards in the workplace.

Broadly speaking, two main strategies have been proposed—controlling levels of substances causing reproductive hazards and removing susceptible workers while allowing the hazard to exist. The issue came to a head over a decision in 1978 by American Cyanamid to remove all fertile women from jobs in the lead chromate pigment manufacturing section of its plant at Willow Island, West Virginia. After reviewing this decision, the Occupational Safety and Health Administration (OSHA) cited the company under the general duty clause of the Occupational Safety and Health Act, which requires an employer to provide a workplace free of hazards that might cause death or serious physical harm, and fined it $10,000.[30] In early 1980, the Oil, Chemical and Atomic Workers Union and the American Civil Liberties Union sued the company under the 1964 Civil Rights Act on the ground that the company was discriminating unfairly against women.[31]

American Cyanamid argued that its approach is the most practical and economical solution to the problem. One spokesperson stated: "In the real world [having the workplace safe for everyone is] totally unachievable without emasculating the chemical industry. . . . There is no way . . . to always protect [the fetus]. In those instances where we cannot protect the fetus, we are required to move it away from the hazard, and that has to mean moving the mother as well." [32]

The union argued that substances that cause fetal damage are likely to harm both male and female reproductive functions.[33] In addition, both the union and OSHA said that a female worker should not have to choose between fertility and a job.

WIDESPREAD EXPOSURE TO SELECTED TOXIC SUBSTANCES

Three toxic substances to which large numbers of people are or may be exposed are lead, until recently a widely used additive in paint and still an additive in gasoline; caffeine, consumed in colas, coffee, and tea; and diesel exhaust, potentially a problem if the automobile industry in fact converts to diesel-powered cars at the rate currently predicted.

There is still much that is not known about the nature and extent of the health hazards presented by lead and diesel exhausts. There is some, though not conclusive, evidence that diesel exhaust is potentially a serious health hazard. Chronic low-level exposure to lead may cause mental retardation, and caffeine may cause genetic damage. It will probably be a number of years before scientific work on how and in what quantities these substances are hazardous to health is completed. This fact creates a dilemma. Allowing continued or further introduction of these substances into the environment could subject large numbers of people to significant health risks; yet suspending or curtailing use of these substances until the scientific evidence is complete could deprive the public of their benefits, which are significant.

Lead

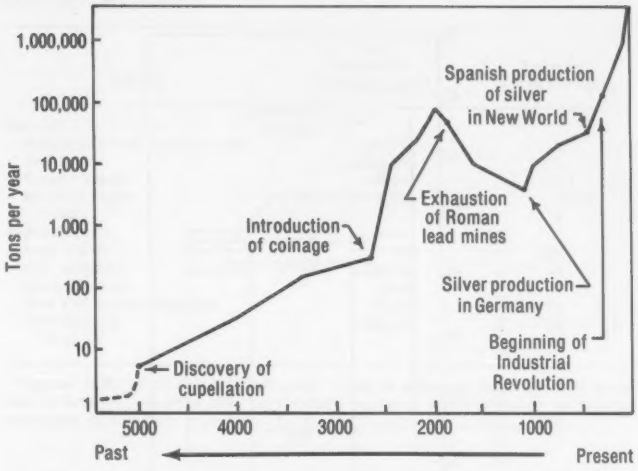
Lead, one of the most useful metals in modern industrial society, has long been known to be highly toxic. Reference to its acute effects on human health, which include convulsions, coma, and death, appeared in a novel by Charles Dickens in 1861.[84] Chronic exposure to low levels of lead is known to produce such difficult-to-diagnose but nevertheless real symptoms as fatigue, headache, poor appetite, clumsiness, and diminished mental capacity.[85] Its increased use over the course of human history is shown in Figure 5–7.

Cases of acute lead poisoning are infrequent in the United States today. But the fact that lead had been used extensively in paints, is still used in gasoline (a use which is currently being curtailed), and is widely used for many other purposes means that virtually all U.S. residents are regularly exposed to low levels of lead. Lead is currently used in the manufacture of batteries and certain ceramic glazes, is produced by iron smelting and burning of coal, and has many other industrial uses. Lead solder is often used to seal "tin" cans. The questions of whether current levels of exposure constitute a serious hazard and, if so, what sources of exposure are most important and/or most amenable to control have engendered considerable controversy.

Scientists and government regulators have identified several important sources of environmental exposure to lead—the ambient air, primarily from motor vehicle emissions and in some areas from smelter emissions; paint, primarily a problem for children living in older deteriorating housing who may eat lead-containing paint chips

Figure 5-7

World Lead Production



Source: D.M. Settle and C.C. Patterson, "Lead in Albacore: Guide to Lead Pollution in Americans," *Science* 207:1171 (1980), reprinted with permission of *Science* (copyright © American Association for the Advancement of Science, 1980).

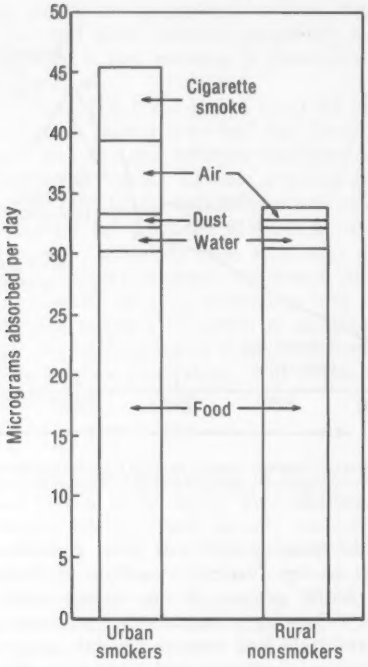
or play in lead-containing dirt and dust; cigarette smoke; and food. According to the National Academy of Sciences, food is responsible for 65–92 percent of the average adult lead intake (see Figure 5–8). Growing plants absorb lead from contaminated soil and water and from lead-arsenate pesticide sprays. In addition, a significant fraction (estimates are as high as 50 percent) of ingested lead comes from canned foods, because of the lead used in the can seams.

Concentrations of lead in the air in the "cleanest" regions of North America are about 10 nanograms per cubic meter (ng/m^3); yet even these relatively low concentrations are 100-100,000 times higher than the ambient concentrations believed to have existed 10,000 years ago.[36] Urban dwellers generally breathe air containing from 500 to 10,000 ng/m^3 of lead. In 1978, EPA promulgated a primary ambient air quality standard of 1,500 ng/m^3.[37]

The chief sources of lead emissions are automobile exhaust and industrial facilities. The leading natural and manmade sources of emissions worldwide are listed in Table 5–3. The major natural source of lead—volcanic dust—is less than 1 percent of the emissions caused by human activity. In an effort to reduce auto-related lead emissions, which EPA estimates at about 88 percent of all manmade emissions, in 1973 EPA began progressive restriction of lead content

Figure 5-8

Sources of Lead Intake in Urban Smokers and Rural Nonsmokers



Source: National Academy of Sciences, *Lead in the Human Environment* (Washington, D.C., 1980), p.119.

of gasoline to a level of 0.5 grams per gallon effective October 1, 1979.[38] As a result of subsequent litigation, the effective date was postponed until October 1, 1980.[39]

The major source of public exposure to lead is food. According to one study, lead pollution is so pervasive in the environment that the lead concentration in the average U.S. diet is 100 times that of prehistoric man's.[40] In addition is the lead which contaminates food in cans that are seamed with lead solder. Although it is generally agreed that the lead content of canned foods has decreased significantly since the early 1970s,[41] scientists do not agree on how serious a source they are. In 1979, the Food and Drug Administration issued an advance notice of proposed rulemaking for lead in food as a first step in setting "action levels" to reduce intake from lead-soldered cans 50 percent in 5 years.[42]

Table 5–3

Global Lead Emissions from Natural Sources and Human Activities

Source	Total production (10^6 kg per year)	Emission (10^6 kg per year)
Natural		
Wind-blown and volcanic dust	200,000	2
Sea spray	1,000,000	<1
Forest foliage	100,000	<0.1
Volcanic sulfur	6,000	0.001
Total		2
Anthropogenic		
Lead alkyls	400	280
Iron smelting	780,000	47
Lead smelting	4,000	24
Zinc and copper smelting	15,000	42
Coal burning	3,300,000	15
Total		400

Source: D.M. Settle and C.C. Patterson, "Lead in Albacore: Guide to Lead Pollution in America," *Science* 207: 1171 (1980), reprinted with permission of *Science* (copyright © American Association for the Advancement of Science, 1980).

In the view of many experts, a serious environmental problem is the effects of lead on small children.[43] A recent study suggests that at an early age even marginally elevated blood-lead levels can have lasting adverse effects.[44] Boston school children who at 3 years of age had blood levels slightly above 30 micrograms per 100 milliliters (μg/100 ml), the level defined as undue lead absorption by the Center for Disease Control, showed noticeable intellectual and behavioral deficiencies at age 7. Children with elevated levels of lead in their baby teeth also showed behavioral deficiencies.

A 1976 study of 2- to 3-year-old children in New York City showed that they had significantly lower blood-lead concentrations than a comparable group studied in 1971. The reason for this improvement is not clear. One analysis suggests that, because it correlates well with lower levels of lead in gasoline, the lead in gasoline may be the chief cause of the elevated blood-lead levels in these urban children.[45] But other experts suggest that eating lead-containing paint chips or flakes in dilapidated housing units and exposure to lead-impregnated dirt and dust are the most important causes of elevated blood-lead levels. No expert disputes the fact that all these sources contribute to elevated blood levels in children. In any case, it appears that a serious problem exists. Although average blood-lead levels among children tested in New York City have fallen from 33 μg/100 ml in 1971 to 23 μg/100 ml in 1976, 19 percent of the black 2- to 3-year-olds tested in 1976 had blood-lead levels exceeding 30 μg/100 ml (the criterion for "undue lead absorption" is more

than 30 μg lead/100 ml blood).[46] Nationally, 6–8 percent of the children examined in a 1978 lead-screening program met this criterion.[47]

Since 1971, when the Congress passed the Lead-Based Paint Poisoning Prevention Act,[48] the Department of Housing and Urban Development (HUD) has spent almost $9 million on lead-based paint hazard abatement research.[49] Other government and private entities throughout the nation have also worked to remove lead-based paint from old housing stock. Some individuals have begun to question whether this effort is the best possible allocation of funds, and others vehemently defend it. In June 1978, HUD asked the National Academy of Sciences (NAS) to study the issue. *Lead in the Human Environment,* published in 1980, provided no definitive answers to many of the questions that it confronted. It concluded that available data are inadequate to assess quantitatively the relative importance of the various sources of lead to which people are exposed and called for continued control of all sources of lead.[50]

Caffeine

Caffeine has been consumed in foods and beverages all over the world for centuries. In the United States, caffeine is primarily consumed in coffee, tea, chocolate, and colas.

The Federal Drug Administration (FDA) has classified caffeine as a multipurpose food substance that is "generally recognized as safe" (GRAS) by experts.[51] GRAS means that a substance is exempt from the premarketing clearance required for food additives. However, the FDA limits the use and concentration of caffeine (to less than 0.02 percent by weight) in colas.

Because of continuing uncertainties about the safety of caffeine, the FDA commissioned the Federation of American Societies for Experimental Biology to evaluate the safety of caffeine.[52] The FASEB reviewed the scientific and medical literature from 1920 to 1974 pertaining to the effects of caffeine on living organisms. It examined microbial, human, and nonhuman cell system studies and rodent studies, which indicated that caffeine may cause increases in spontaneous neuromuscular activity and other changes in animals at doses as low as 2 milligrams per kilogram (mg caffeine/kg body weight).[53] The average adult consumes 2.4 mg caffeine/kg body weight per day.[54] Table 5–4 indicates mean consumption of caffeine by age group.

The caffeine in about 3 cups of coffee consumed successively may impair human verbal performance.[55] Higher levels of consumption may produce symptoms indistinguishable from anxiety neurosis.[56]

Of particular concern to the FASEB was whether caffeine could cause birth defects. The Federation observed that "caffeine causes chromosomal damage in certain microbial and other non-mammalian test systems, and caffeine has similar effects at high concentrations

Table 5–4

Mean Human Consumption of Caffeine

Age (years)	Source (mg per kg body weight per day)	
	All •	Soft drinks
<1	0.70	0.17
1–5	1.4	0.49
6–11	1.0	0.31
12–17	0.87	0.21
18+	2.4	0.18

• Includes coffee, tea, soft drinks, and chocolate.

Source: A.W. Burg, testimony, Federation of American Societies for Experimental Biology, Select Committee on GRAS Substances, public hearings on caffeine, September 26, 1977, cited in Federation of American Societies for Experimental Biology, *Evaluation of the Health Aspects of Caffeine as a Food Ingredient*, SCOGS–89 (Washington, D.C.: U.S. Food and Drug Administration, 1978), p. 7.

on mammalian cells in culture in several *in vitro* tests. However, *in vivo* tests utilizing mice and rats have failed to demonstrate mutagenic (chromosomal) effects of caffeine." [57]

A relationship between congenitally malformed babies (teratogenetic, from the Greek *teras,* monster) and caffeine has been found in most mice and rat studies.[58] Nonetheless, in an epidemiological study of nearly 1,400 human mothers, caffeine was not found to be associated with congenital malformation in children.[59]

Inconsistencies in evidence raise many scientific and regulatory questions. The medical and scientific community largely acknowledges the validity of extrapolating animal cancer test data to humans. Chemicals that produce malignancies in rodents are believed to be highly likely to cause cancers in humans. In the field of teratology there is no agreement on the validity of extrapolation. There are also serious questions about the significance for human health of chromosomal damage in cell culture tests. These uncertainties are reflected in the two major conclusions reached in the FASEB study:

> While no evidence in the available information on caffeine demonstrates a hazard to the public . . . uncertainties exist requiring that additional studies be conducted.
>
> It is inappropriate to include caffeine among the substances generally recognized as safe (GRAS). At current levels of consumption of cola-type beverages, the dose of caffeine can approximate that known to induce such pharmacological effects as central nervous system stimulation.[60]

To try to determine whether caffeine can cause birth defects, the FDA initiated two additional studies in 1979. In one, caffeine was force-fed to pregnant rats, thus exposing them to high doses. In the

other, caffeine was added to pregnant rats' drinking water. The first study conclusively demonstrated that caffeine is an animal teratogen at doses not much higher (proportionally) than high-average human consumption.[61] The second study is not complete. Concurrently with these studies, the FDA has considered regulatory options, among them:

- Requiring warning labels on such products as coffee and tea, indicating that pregnant women should reduce their consumption of caffeine.
- Removing caffeine from the GRAS list and as a required ingredient of cola drinks. (FDA regulations now require that any product referred to as a "cola" contain some caffeine.)
- Requiring warning labels on drugs that contain caffeine.
- Initiating consumer education programs.[62]

The FDA Commissioner is not prepared to issue warnings about caffeine consumption on the basis of present scientific knowledge, but he advises pregnant women as a general precaution to watch their diets carefully, to avoid drugs when possible, and to be moderate in their use of stimulants.

Diesel Exhaust

The United States may be on the verge of a large-scale switch to diesel-powered vehicles. These vehicles are desirable as a means of conserving energy because they achieve significantly better fuel economy than gasoline-powered vehicles (about 25 percent more miles per gallon and 10 percent lower fuel price per gallon than gasoline).[63] It is expected that consumers will buy a substantially greater number of these U.S.-manufactured vehicles in the next few years, perhaps as many as 1.75 million in 1985, which would be seven times the number in 1980.[64] Much of this shift to diesel-powered vehicles may take place before all the evidence on their environmental hazards is in.

Diesel-powered light vehicles presently emit about 1 pound of particulates per 1,000 miles driven.[65] This figure is 20–100 times higher than comparable gasoline-powered catalyst-equipped vehicles. The EPA particulates emission standard issued in early 1980 requires diesel engine emissions to be reduced to no more than 20 times the particulates emitted by gasoline engines.[66] Although diesel engines emit less carbon monoxide than do gasoline engines equipped with catalytic converters, the higher particulate emissions are of concern to many health experts.

When inhaled, the particulates and associated materials emitted by diesel engines enter the deep lung and remain for a significant time. Some chemically extracted fractions of diesel exhaust particulates have been shown to produce mutations and cancer-like changes in several types of animal and bacterial tests.[67] These responses suggest that there are animal (and probably human)

carcinogens in diesel exhaust products and that an increase in human cancers could occur from large-scale use of light-duty diesel vehicles.

EPA, the Department of Energy (DOE), and the National Institute for Occupational Safety and Health (NIOSH) have undertaken substantial research to evaluate the potential health effects of human exposure to diesel exhaust products. Exposure to diesel particulates may aggravate chronic bronchitis, emphysema, asthma, and respiratory infections. The DOE is investigating both the carcinogenic and noncarcinogenic health effects of diesels.

NIOSH is conducting epidemiologic studies of workers exposed to diesel exhaust. The studies include miners, railroad roundhouse workers, and garage mechanics. Interim results should be available in mid-1982.

EPA is attempting to quantify the cancer risks from diesel exhaust. The extent of the risk depends on the extent of exposure of the population (how many are exposed to how much exhaust) and the potency of the carcinogens in the emissions. Because most of the urban population could be exposed to significant concentrations of diesel exhaust, even a weak carcinogen could mean a significant number of excess deaths.

EPA has estimated the effects of using diesel fuel in U.S. light-duty vehicles.[68] The EPA particulate emissions standards for light-duty motor vehicles are 0.6 grams per mile (g/m) for model year 1982 and 0.2 g/m for model year 1985.[69] Gasoline-powered light-duty vehicles easily meet these standards, but diesel-powered vehicles will require additional control technology. EPA is expected to issue particulate emissions standards for heavy duty vehicles and engines late in 1980. Whether further action to control diesel exhaust is warranted depends upon results of research on the carcinogenic potential of diesel exhaust.

To permit introduction of diesel engines, in early 1980 EPA waived its 1981 and 1982 nitrogen oxides (NO_x) emissions standard (1 g/m)[70] to allow 1.5 g/m for some diesel-powered light-duty vehicles. EPA took this action because present NO_x control devices tend to increase particulate emissions, and the dangers of the higher particulate emissions appeared greater than those of higher NO_x emissions. EPA believed that this action (provided for in the 1977 Clean Air Act Amendments) was necessary to allow these manufacturers to achieve the new particulate standards nationwide beginning in model year 1982.

To obtain a waiver, a manufacturer must demonstrate, among other requirements, that the public health will not be endangered. The Natural Resources Defense Council (NRDC) challenged these waivers in court in the winter of 1980,[71] arguing that both the EPA particulate standard and NO_x waiver endanger the public health and violate legal principles of the Clean Air Act. EPA maintained that regulating the diesel pollutants in a manner that would not impede the growth of diesel manufacturing was not possible. The

NRDC cited an important decision [72] upholding EPA authority to set standards that in effect reduced the sales of some vehicles so long as the basic demand for automobile transportation could be satisfied. The NRDC also maintained that improved fuel economy in conventional automobiles reduces the urgency for use of diesels and that several manufacturers may use diesels not to improve fuel economy for the entire fleet but to allow them to market a higher proportion of larger model cars.[73]

ISSUES IN THE REGULATION OF TOXIC SUBSTANCES

HAZARDOUS WASTE DISPOSAL

The nation continues to grapple with the very difficult problem of hazardous wastes generated by the chemical and other industries. Early in 1980, EPA promulgated new regulations under the Resource Conservation and Recovery Act [74] implementing cradle-to-grave controls for handling hazardous wastes. As the EPA regulations were being issued, some firms were seeking to export hazardous wastes apparently to avoid the costs and requirements for safe disposal in the United States. EPA and the Department of Justice have continued their efforts to identify and clean up abandoned and inactive dumpsites—the legacy of unsound hazardous waste disposal. In December 1980, the Congress passed and the President signed into law "superfund" legislation giving EPA needed authority and resources to clean up spills of hazardous substances and abandoned dumpsites systematically.

Discovery of Hazardous Waste Dumpsites

Severe environmental contamination from improper disposal of toxic wastes continues to come to light. Pollution of ground water and other drinking water supplies is a serious threat to public health. This problem is discussed in detail in Chapter 2, Water Quality. EPA has 7,200 waste disposal sites under active investigation. In addition to the Love Canal waste site, other areas were in the news:

- Residents of Legler, a rural community in the Pine Barrens of southern New Jersey, complained of kidney ailments, cancer, miscarriages, sores, and skin rashes. The suspected cause was toxic chemicals leaching into the town's drinking water source from a 135-acre landfill operated by Jackson Township.[75] The Township Board of Health had advised residents to stop drinking from their wells in late 1978.

  Licensed by the state in 1972, the landfill was not authorized to accept industrial liquid wastes, but toxic wastes were illegally dumped there. According to a resident, the Township welcomed

dumpers from all over the state, and, according to the Township Superintendent of Public Works, the dump accepted more than 100,000 gallons of wastes per day at the peak.[76] The Township has denied knowingly accepting toxic wastes, but in a suit filed to close the dump in February 1980, New Jersey alleged that the Township had known since 1975 "that dangerous chemicals were leaching from the landfill into the Cohansey aquifer." [77]

According to the New Jersey Department of Health, the compounds that have penetrated the aquifier "are in most part extremely toxic and hazardous." [78] In addition to benzene, chloroform, trichloroethylene, tetrachloroethane, and dichlorethylene—all known carcinogens—other chemicals found there affect the kidneys, nervous system, blood, bone marrow, respiratory tract, and digestive system. Ninety-six families are suing the Township and have requested that $50 million in bonds be posted to pay for cleanup and for health and other damages.[79] Township residents have also sued the former site operator.[80] The Township has borrowed $1.2 million from the state for a water treatment plant and 7.5 miles of piping to provide wells.

- Between 1972 and 1979, approximately 6,000 pounds of plastic and other wastes were buried in the Sullee landfill near Gassville, Arkansas.[81] The owner of the site was repeatedly warned by state officials that he was violating pollution regulations by not keeping the wastes buried. In November 1979, the dump ignited and burned out of control for 12 days, producing a cloud of toxic hydrogen chloride. Dangerous levels (as high as 15 parts per million) of the gas were detectable more than 2 miles away, prompting the Governor to declare a state of emergency. Hydrogen chloride gas forms highly corrosive hydrochloric acid when it is mixed with water. In high concentrations hydrogen chloride inhalation is fatal; in low concentrations, inhalation can produce irritation, burns, and ulceration of the skin, eyes, and mucous membranes; reduced vision and blindness; laryngitis; bronchitis; and pulmonary edema.[82] Use of water on the fire was delayed because of concern that hydrochloric acid in the runoff would harm local underground water supplies or the nearby White River. State fire training academy personnel finally put out the blaze.

- Over the years, hundreds of thousands of pounds of dangerous chemical wastes, including TRIS (tris(2,3-dibromopropyl) phosphate), DDT, and benzene, were dumped in a wooded area near the Michigan Chemical Co. plant in St. Louis, Michigan. Now called Velsicol Chemical Co., the plant closed in 1978 after the state had begun permit revocation proceedings. The dumpsite later became part of a golf course. Deadly chemicals seeped into the Pine River from the golf course and the plant. In fact, they continue to seep from the plant into the River.

  Five miles from the plant, in the Gartiot County landfill, the

Michigan Department of Natural Resources has found large quantities of highly toxic chemicals, including the fire retardant PBB and other brominated and chlorinated organic chemicals. The landfill may contain over 100,000 pounds of PPB—probably more PBB than any other dumpsite in the country. These areas are among the most heavily contaminated by chemicals in the state.[83]

Michigan Chemical and Velsicol both used the dumpsite. Alleging that Velsicol failed to warn workers about the dangers of the chemicals produced and disposed of at the plant, workers and the local Oil, Chemical and Atomic Workers Union have filed a $250 million suit against the company.[84] The suit alleges that the workers suffered from stress, swollen joints, headaches, and other ailments.

The state and EPA are seeking to force Velsicol to clean up the golf course and plant site, at an estimated cost of several million dollars.[85]

In its report on hazardous waste disposal, the Subcommittee on Oversight and Investigations of the House Interstate and Foreign Commerce Committee summarized the problem:

> The hazardous waste disposal problem cannot be overstated. The Environmental Protection Agency (EPA) has estimated that 77,140,000,000 pounds of hazardous waste are generated each year, but only 10 percent of that amount is disposed of in an environmentally sound manner. Today, there are some 30,000 hazardous waste disposal sites in the United States. Because of years of inadequate disposal practices and the absence of regulation, hundreds and perhaps thousands of these sites now pose an imminent hazard to man and the environment. Our country presently lacks an adequate program to determine where these sites are; to clean up unsafe active and inactive sites; and to provide sufficient facilities for the safe disposal of hazardous wastes in the future.[86]

Disposal Options

Hazardous wastes are produced in many segments of society: industry, hospitals, research facilities, and government. Industry is by far the largest source; according to EPA estimates, the chemical and allied products industry produces 60 percent of all industrial hazardous wastes, as shown in Table 5–5. Industrial wastes are also generated in the manufacture of automobiles, energy, paper, plastics, clothing, rubber, paint, pesticides, medicines, and most other products used daily. Table 5–6 lists some common products and the potential hazardous wastes generated in their manufacture.

The Resource Conservation and Recovery Act (RCRA) defines a hazardous waste as one that may cause or significantly contribute to serious illness or death or that poses a substantial threat to human health or the environment when improperly managed.[87] Using the RCRA definition, EPA has compiled a list of hazardous wastes. It includes 16 categories of hazardous wastes from nonspecific sources, such as spent halogenated solvents (e.g., tetrachloroethylene) used

Table 5–5

Total U.S. Industrial Hazardous Wastes

Source	Percentage of total
Chemical and allied products	50
Machinery (except electrical)	10
Primary metals	8
Paper and allied products	6
Fabricated metal products	4
Stone, clay, and glass products	3
All others	9

Source: U.S. Environmental Protection Agency, Office of Water and Waste Management, *Everybody's Problem: Hazardous Waste* (Washington, D.C.: U.S. Government Printing Office, 1980), p. 14.

Table 5–6

Common Hazardous Wastes

Chemical	Use	Manufacturing hazard
C–56	Bug and insect killer	Acutely toxic, suspected carcinogen
Trichloroethylene (TCE)	Degreaser	Suspected carcinogen
Benzidene	Dye industry	Known human carcinogen
Curene 442	Plastics industry	Suspected carcinogen
Polychlorinated biphenyls (PCBs)	Insulators, paints, and electrical circuitry	Acutely toxic, suspected carcinogen
Benzene	Solvent	Suspected carcinogen
Tris	Fire retardant	Suspected carcinogen
DDT	Bug and insect killer	Acutely toxic
Vinyl chloride	Plastics industry	Known human carcinogen
Mercury	Multiple uses	Acutely toxic
Lead	Multiple uses	Acutely toxic, suspected carcinogen
Carbon tetrachloride	Solvent	Acutely toxic, suspected carcinogen
Polybrominated biphenyls (PBBs)	Fire retardant	Effects unknown

Source: Eric Sharp and Doug Hall, "Haulers Fouling State with Deadly Chemicals," *Detroit Free Press*, December 12, 1979, p. 19A (copyright ©, reprinted with permission).

in degreasing, and wastes from specific sources, such as pesticide production residues (e.g., chlordane), as well as 361 chemicals that are deemed hazardous if discarded.[88] Other wastes will be listed periodically. EPA defines as hazardous any waste that meets one of the following criteria:

- Ignitability—wastes that pose a fire hazard during routine management. Fires not only present immediate dangers of heat and

smoke but also can spread harmful particles over wide areas.

- Corrosivity—wastes requiring special containers or segregation from other wastes because of their ability to dissolve toxic contaminants.
- Reactivity—wastes that tend to react spontaneously, to react vigorously with air or water, to be unstable to shock or heat, to generate gases, or to explode.
- Toxicity—wastes that, when improperly managed, may release toxicants in sufficient quantities to pose a substantial hazard to human health or the environment.[89]

In 1980, an estimated 56 million metric tons of hazardous wastes will be generated nationwide.[90] Approximately 60 percent of the wastes are generated in 10 states (New Jersey, Illinois, Ohio, California, Pennsylvania, Texas, New York, Michigan, Tennessee, and Indiana). According to EPA, 90 percent of them are being disposed of in an environmentally unsound manner—in unsecured landfills, through improper incineration, or by illegal "midnight dumping."[91] Substantial research and development are necessary to refine existing technologies and develop new ones and to reduce costs, although technologies do exist for environmentally sound management of some hazardous wastes.

Sound management of hazardous wastes means more than just careful disposal. It requires consideration of characteristics, volume, and location of the wastes. According to EPA, the desired options for managing hazardous wastes disposal, in order of priority, are to

- Minimize the amounts generated by modifying the industrial process
- Transfer the wastes to another industry that can use them
- Reprocess the wastes to recover energy or materials
- Separate hazardous from nonhazardous wastes at the source, thus reducing the costs of handling, transportation, and disposal
- Incinerate the wastes or subject them to treatment that makes them nonhazardous
- Dispose of the wastes in a secure landfill (one that is located, designed, operated, and monitored, even after it is closed, in a manner that protects life and the environment).[92]

On the principle that one company's wastes may be another's raw materials, transfer of a hazardous waste to another industry has become a viable option—a materials exchange is equipped to handle, treat, and physically exchange wastes, and an information exchange acts as a clearinghouse, leaving generator and potential purchasers to negotiate directly. The first information exchange was established in The Netherlands in 1972. At least 20 information exchanges and 3 materials exchanges are now operating in the United States.[93]

It is probable that only a small percentage of hazardous wastes is suitable for exchange. Unmixed wastes stand the best chance of being exchanged. In addition, wastes are more likely to be ex-

changed when the purchaser is in the same or a nearby locality; proximity minimizes transportation costs.

An additional option is recovery of energy or materials, which may well become a more attractive alternative with increasing shortages of raw materials and tighter restrictions on disposal of wastes. Many wastes contain valuable materials. Their extraction from concentrated wastes requires less energy and generates less water and air pollution than the mining and processing of virgin materials. Because only a small percentage of wastes is suitable for recovery, new technologies must be developed to make it a viable option for many waste producers.

Incineration, when properly done, is a proven method of destroying some toxic organic wastes without posing a threat to the environment. Incineration, however, is extremely energy intensive and costly.

Hazardous wastes can be processed physically or biologically to render them less hazardous or nonhazardous. The physical processes include carbon or resin adsorption, distillation, centrifugation, flocculation, sedimentation, reverse osmosis, and ultrafiltration. Chemical processes include fixation into solids that are more readily disposed of, neutralization, exchange to remove heavy metals, oxidation, and precipitation. The biological processes are activated sludge treatment to destroy organic compounds, composting of organic-rich wastes, trickling filters to promote decomposition, and controlled application to land to degrade organic compounds.

EPA has estimated the costs of each of these technologies. The range is from $2 to $25 per metric ton for land spreading to $75 to $2,000 per metric ton for incineration, as shown in Table 5–7.

Sound disposal of hazardous wastes is costly, but it is ultimately less costly than improper disposal. At Love Canal, in Niagara Falls, New York, for example, the estimated cost of proper disposal would have been less than $2 million; as of May 1980, more than $36

Table 5–7

Costs of Environmentally Sound Methods for Disposal of Hazardous Wastes

Method	Cost (dollars per metric ton)
Land spreading	2–25
Chemical fixation	5–500
Surface impoundment	14–180
Secure chemical landfill	50–400
Incineration (land based)	75–2,000
Physical, chemical, or biological treatment	Varies

Source: U.S. Environmental Protection Agency, Office of Water and Waste Management, *Everybody's Problem: Hazardous Waste* (Washington, D.C.: U.S. Government Printing Office, 1980), p. 15.

million had been spent by state and federal governments for cleanup, relocating residents, health and environmental testing services, and other associated expenses.[94] Health care and liability costs are not included; nor are the unquantified costs of fear and disruption of the lives of Love Canal residents. A federal suit against the company charged with responsibility for the Love Canal disaster is seeking a $45 million trust fund to ensure cleanup and payment of other costs.[95] The suit is discussed in a later section of this chapter.

The Resource Conservation and Recovery Act

Subtitle C of the Resource Conservation and Recovery Act requires safe disposal of hazardous wastes. In February and May 1980, EPA issued major regulations implementing Subtitle C.[96] The regulations will become effective in November 1980. However, generators, transporters, disposal facility operators, and others subject to the regulations who are engaged in business as of August 1980 must provide specific information to EPA by August 1980 in order to continue handling hazardous wastes after November. EPA expects to receive approximately 300,000 of these notices. Others cannot enter the hazardous waste business without first obtaining a permit from EPA.

The regulations define hazardous wastes and establish a cradle-to-grave management system, including standards for generators of hazardous wastes, standards for transporters, and interim standards and permit requirements for owners and operators of facilities that treat, store, or dispose of hazardous wastes. (Permanent facility standards and permit requirements are expected to be issued in late 1980.) EPA will issue interim permits to disposal site operators who provide timely notice of activities, file timely applications, and meet the interim permit standards. EPA expects that it will take more than 5 years to issue the 30,000 permanent permits needed.

The keystone of the hazardous wastes program is the manifest system. The regulations require a waste generator to prepare a manifest for the hazardous wastes. The manifest is to track movement of the wastes from the point of generation to the point of disposal. Several steps will be taken. First, a generator must check the EPA hazardous wastes list. If a waste is hazardous, it must be properly packaged and labeled and a manifest provided to the transporter. The transporter may deliver the waste only to a permitted disposal site.

The regulations also establish standards for state hazardous waste programs. EPA may authorize a state to operate a hazardous waste program in lieu of the federal program if the state meets the standards. Failure to comply with the Act is punishable by civil penalties and, in certain cases, by fines and imprisonment.

Enforcement of Hazardous Waste Laws

In December 1979, the Department of Justice and the Environ-

mental Protection Agency filed the largest environmental protection action to date.[97] The suits charged Hooker Chemical Company, its parent company Occidental Petroleum Corporation, and Olin Corporation with violating federal pollution laws and endangering human health and the environment at Love Canal and three other sites in Niagara Falls, New York. The government is seeking $125 million—$68 million from Hooker for cleanup at three sites, $50 million from Hooker and Olin for cleanup of the fourth site, and $7 million from Hooker for reimbursement of federal funds already spent to clean up the Love Canal area. None of the four sites is currently in use, but between 1942 and 1975, the two companies disposed of more than 265,000 tons of wastes at the sites.

Environmental problems persist at the four sites. In May 1980, upon request of the Governor of New York, the President again declared Love Canal an emergency under the Federal Disaster Relief Act,[98] making all residents of the Canal area immediately eligible for temporary (up to 1 year) housing and relocation assistance.[99] Chemicals from a site known as the "S" area landfill have spread to the nearby Niagara Falls water treatment plant and have infiltrated it, posing a threat to the city water supply. However, in tests conducted in November 1979, chemicals were not detected in drinking water at a concentration that is a "present hazard."[100] Chemicals, including dioxin, were found to be seeping from another site into a nearby creek and into the Niagara River, and there have been reports of chemical explosions at some locations.

In addition to seeking cleanup costs, the government has asked the court to order the companies to monitor the sites for future air and water contamination, to pay for complete medical studies of the residents of the area, and to purchase the homes of residents in the affected area. In December, the Department of Justice and the state of California also filed a suit against Hooker and its subsidiary, Occidental Chemical, both owned by Occidental Petroleum, seeking millions of dollars in fines and cleanup costs for pollution of drinking water wells in Lathrop.[101]

These and 25 other suits filed as of July 1980 are part of a new emphasis on enforcement of hazardous water pollution laws.[102] The Justice Department and EPA have established a special strike force to investigate and prosecute hazardous waste pollution. The strike force expects to file more than 50 lawsuits by the end of 1980.[103]

Export of Hazardous Wastes

Few of the technologies for safe waste disposal have been widely used. Only 2 percent of hazardous wastes, for example, are reclaimed or recycled. The high cost of proper disposal (particularly when compared to improper disposal), lack of uniform legal requirements and enforcement, and the shortage of safe disposal sites are probably the major reasons for industry's failure to dispose of wastes properly. The RCRA regulations and increased enforcement of laws

affecting disposal will require that industry adopt safe, yet initially more costly, means of disposal. In looking for alternatives, some industries may see export of wastes as expedient.

The Nedlog Corporation brought this issue to public attention in 1979. In exploratory discussions with Sierra Leone, Nedlog proposed to pay up to $25 million annually in lieu of taxes over the next 5 years in return for permission to dispose of hazardous wastes in Sierra Leone. Under the plan, toxic wastes would be shipped to Port Pepal and transported by rail to the interior of the state, where Nedlog would consider constructing a recycling recovery plant. Unclaimed residues from the plant would be dumped in an abandoned iron mine nearby.[104]

Upon learning of the proposal, the State Department immediately informed the Sierra Leone government of the potential dangers of hazardous waste disposal and requested information from embassies in developing countries of any plans to receive toxic wastes from the United States. As word of the Nedlog proposal became public in Sierra Leone, its government canceled exploratory talks. Subsequently, there were other press reports concerning Nedlog's efforts to arrange disposal in Liberia and Chile and similar efforts by others in Nigeria, Senegal, and Haiti.[105] Information also came to light concerning transportation of toxic wastes from California and Texas for disposal in Mexico.[106]

It is not known how much, if any, toxic wastes have been transported to less developed countries or, in fact, how they have been disposed of. As of mid-1980, EPA, the State Department, the Commerce Department, and other federal agencies were meeting to consider whether and in what way the Export Administration Act[107] could be used to monitor and control the export of hazardous wastes. Once EPA's RCRA regulations become effective in November 1980, generators will be required to notify EPA of the proposed export of hazardous wastes.[108]

Superfund Legislation

In 1979, the President proposed the Oil, Hazardous Substances, and Hazardous Waste Response, Liability, and Compensation Act.[109] The proposal was necessary because the RCRA is not retroactive.

In December 1980, after consideration of several proposals,[110] the Comprehensive Environmental Response, Compensation, and Liability Act became law.[111] This landmark legislation establishes a $1.6 billion fund for cleanup of spills of hazardous substances and for cleanup of inactive hazardous waste disposal sites. The fund can be used to clean up releases into the environment when no responsible party can be identified or when the responsible party is unwilling to clean up. The government can sue to recover its expenditures. Part of the fund (87.5 percent) is to be financed by a tax on oil and specified chemicals; the remaining 12.5 percent will be appropriated.

COMPENSATION OF VICTIMS

Whether, how, and when to compensate people for health damages caused by exposure to toxic substances have raised legal and social questions. Historically, anyone injured by the action of another—in a car accident, for example—could sue the party causing the injury and be compensated for medical costs, lost wages, property damage, and other expenses. But for some cancers, lung diseases, birth defects, and other conditions with possible environmental origins, it is often difficult to win a lawsuit. Frequently such diseases have multiple causes and long latencies. Because of the time lag between exposure to a substance and manifestation of disease, it is often impossible to identify the agent causing a disease or the polluter responsible for exposure to it.

The issue of compensation for environmentally related diseases has taken on an immediacy as new and disturbing facts have emerged about the effects of some chemicals and substances on human health. Such disclosures have led to numerous lawsuits against private companies and the federal government and to other efforts to obtain compensation through government programs. In recent years, shipyard workers and others who have contracted asbestosis, lung cancers, and mesothelioma have sued Johns-Manville, Raybestos, other asbestos manufacturers, and the federal government[112]; residents near Love Canal have sued the Hooker Chemical Company for property damage and for miscarriages, cancer, birth defects, and other serious illnesses allegedly caused by chemical contamination at an abandoned hazardous waste disposal site[113]; and residents of Jackson Township, New Jersey, have sued the SCM Corporation, a former operator of a dumpsite which allegedly contaminated drinking water supplies, claiming that cancer and kidney ailments resulted from the chemical contamination.[114] Coal miners who have contracted pneumoconiosis continue to seek disability benefits and compensation from mine owners and from a special federal trust fund established under the Black Lung Benefits Reform Act.[115]

Residents of Nevada and Utah during the 1950s have claimed that exposure to radiation from atmospheric atomic testing caused leukemia and other cancers and serious diseases. Claims have been filed with the Veterans Administration by veterans who were at atomic test sites, and lawsuits have been instituted by nonveterans who were downwind of the sites.[116] Other veterans, claiming that the Agent Orange (a 50:50 mixture of technical grades of 2,4-D and dioxin-contaminated 2,4,5-T)—a defoliant used extensively in Vietnam—caused birth defects, cancers, and chronic illnesses years later, are also seeking compensation.[117] In the coming years, there will surely be additional efforts to obtain compensation.

These suits and other actions give rise to two primary questions: first, whether the legal system, in conjunction with government programs, enables people with environmentally caused diseases to obtain

compensation for their injuries and, second, whether these legal and government systems provide any deterrents to pollution.

Identifying Causes of Environmentally Related Disease

Identifying and compensating victims is complicated by the characteristics of environmentally caused disease. The causes of some diseases are readily identified—rare forms of cancer, for example. But even then, there may be several possible sources of exposure. Other environmentally related illnesses are clinically indistinguishable from diseases of non-environmental origin or from the aging process. Cancers, and possibly other diseases, are latent for 5–40 years or more. Interactive or synergistic effects of multiple exposures over long periods present further complications.

Asbestos exposure illustrates the point. Asbestos, a mineral fiber of variable length and shape, has found more than 2,000 distinct uses because of its heat-resistant and electrical properties, tensile strength, and immunity to chemical attack. Industries in which asbestos has been used include the manufacture and installation of brake and clutch linings, cement production and application, the manufacture and installation of furnace and kiln lining, paint production, paper manufacturing, plastic manufacturing, plumbing, roofing tile production and installation, and shipbuilding. Asbestos has also been used in numerous consumer products from hair dryers to patching plaster.[118]

Several crippling and often fatal diseases are now linked to asbestos exposure—asbestosis, a chronic lung disease, and various cancers. For asbestosis, the latency averages 10–20 years. The two major asbestos-related cancers are lung cancer and mesothelioma, a rare cancer of the lining of the lung and abdominal cavity. Asbestos-induced lung cancer has a 15- to 40-year latency, and it can occur after relatively low dose exposure of short duration. It is indistinguishable from other lung cancers. Mesothelioma has no known cause other than asbestos. Its average latency is longer than for asbestosis or lung cancer.[119]

Asbestos effects are also a good example of the problem of synergism. Studies indicate that smoking and asbestos exposure combined exert a multiplicative effect on the risk of lung cancer death.[120] In one study, the risk of dying from lung cancer was observed to be eight times greater among asbestos workers who smoke than among smokers in the general population. For asbestos workers who smoke, the risk is 92 times greater than for nonsmokers.[121] Smoking appears to increase the risk of asbestosis deaths by a factor of 2–3 but has no apparent effect on mesothelioma.[122]

Sources of Compensation

Compensation for environmental disease has not been considered systematically. State-based tort law, private and government insur-

ance, and social welfare programs provide medical, disability, or other compensation under some circumstances. These programs vary in terms of requirements for assistance to the injured and the degree to which it is provided. Some systems require that a connection be established between the source of exposure and the disease if compensation is sought; others do not. Some systems also require that fault be demonstrated—that is, a party must be shown to be legally responsible for causing the disease.

Under the tort liability systems, parties are compensated only when a sufficient relationship is shown between harm and particular activities. The tort system is fault based because the damaged individual must establish that a particular party was legally responsible for causing the injury, e.g., was negligent. In a pollution-related lawsuit, the damaged party would ordinarily have to prove as a probability that exposure to a particular pollutant emitted by a specific source caused the disease.[123] But as noted earlier, it is impossible to prove scientifically and medically in any but the clearest cases. Often there is no scientifically valid test method or study to establish a causal relationship between the pollutant and the disease. The high cost of conducting health effect studies, the absence of data on exposure levels, and some statutes of limitation requiring that a lawsuit be brought within 2–4 years of exposure—even though the disease is not evident until 5 or more years after exposure—may also prevent the bringing of a suit or raise substantial barriers to success.

In contrast to the tort system, the Social Security Disability Insurance Program (SSDI), operated by the Social Security Administration, compensates for lost wages and medical costs to insured disabled individuals regardless of the cause of the disability.[124] The SSDI was established in 1956 to provide income support for workers with long-term total disabilities.[125] To qualify for benefits, individuals must meet minimum contribution and work requirements.[126] The SSDI is financed by equal contributions from employees and employers. In 1978, 2.8 million disabled workers and 2 million dependents drew about $13 billion in benefits.[127] How many were compensated for an environmentally related disease is unknown. The Department of Labor reports that, of the 652,000 long-term totally disabled adults in 1974 who perceived their disability to be caused by an occupational disease, 369,000 (57 percent) received Social Security benefits.[128] By contrast, only 5 percent of those who perceived their disability to be caused by occupational disease received workers' compensation.[129]

State workers' compensation is causation dependent; a relationship between the disease and workplace must be established before a worker is eligible for benefits.[130] Underlying all workers' compensation laws is the concept of no-fault liability insurance designed to ameliorate the difficulty of obtaining and defending compensation claims for job-related disabilities in the tort system. In workers' compensation programs, employees' rights to bring legal action

against employers are abolished in exchange for specified income, medical payments, and rehabilitation services. Through mandatory insurance, employers spread the risk of potentially large awards in litigation. Premiums for workers' compensation are generally paid by the employer. Nationally, however, about 1 percent of employers do not pay premiums to insurance companies or state funds; rather, they remain directly responsible for awards.[131]

An analysis of the data collected by the Department of Labor in its 1975 Survey of Closed Workers' Compensation Claims suggests the difficulty of obtaining compensation for a disease resulting from an environmental exposure. Approximately 60 percent of disease cases and 55 percent of heart cases for which compensation was eventually granted were contested (a formal or informal hearing was held to resolve issues in the claim). This situation is in marked contrast to accident cases, in which only about 10 percent are contested.[132] Causality was the contested issue in 73 percent of occupational disease cases—but in only 21 percent of accident cases.[133]

The Department of Labor reports that there were approximately 7.8 million workers' compensation awards in 1978—6 million medical and 1.8 million disability awards. Less than 2 percent of the 1.8 million disability awards were for occupational diseases.[134]

Other federal programs provide some compensation to individuals. For many of these programs, the primary goal is not compensation to victims of pollution-related diseases. Yet to some degree that may be the net effect. The programs include:

- The Federal Employer's Liability Act[135] compensates railroad workers for occupationally related injuries; the system is fault based and is similar in operation to the state tort system.
- The Federal Longshoremen's and Harbor Worker's Compensation Act[136] instituted a no-fault system operated by the Labor Department to compensate certain maritime employees who are generally not covered by state workers' compensation programs; the system is similar to state workers' compensation programs.
- The Black Lung Benefits Act[137] compensates coal miners suffering from black lung and other respiratory ailments arising from coal mine employment. Mine operators are responsible for claims resulting from employment after December 31, 1969; a trust funded by a coal excise tax and administered by the Department of Labor provides compensation to miners whose employment ended before 1970 or when a responsible mine owner is not available.

Compensation from other sources is available as well, including private pensions, medical and disability insurance, Medicare and Medicaid,[138] Social Security,[139] welfare,[140] and veterans' benefits.[141]

The Department of Labor has reviewed the major sources of income maintenance for severely disabled individuals for 1972 and 1974. The results are summarized in Table 5–8. This review suggests that the costs of making income available to those suffering an environmentally related disease of occupational origin are being

borne primarily by the general public through Social Security, welfare, and the Veterans Administration. As of 1974, only 5 percent of the individuals who reported severe disability from an illness perceived to be occupationally related received workers' compensation. Indeed, according to the Labor Department, in 1972, 26 percent of disabled adults ages 20–64 who perceived their disease to be occupationally related received no income support from public or private programs; in 1974, the figure was 22 percent.[142]

Effectiveness of Programs as Deterrents to Pollution

Some economists believe that requiring a polluter to compensate persons injured by pollution would act as a deterrent to pollution.

To the extent that compensation to the victims can force internalization of the social costs of use of toxic substances, it may have far-reaching implications for controls. If forced to pay the full costs for use of toxic substances, including health and safety costs, companies may find it profitable to manufacture only those products that the public deems essential. Imagine the potential effect on asbestos manufacturing if the cost of asbestos reflected its full share of the health care and other costs of the cancers and lung diseases associated with asbestos and now borne by the public.

According to numerous studies, including the report of the National Commission on State Workmen's Compensation Laws[143] and Labor's report on occupational disease,[144] state workers' compensation has done little to encourage prevention. In theory, premium rates make employers internalize the costs of accidents and diseases in partial proportion to incidence, and workers' compensation thereby serves as an incentive to reduce workplace hazards.

Employers' compensation premiums represent less than their share of the full social costs of each additional disability. Approximately 10 percent of the workforce is not covered (farmworkers, for example)[145]; compensation is generally inadequate (compensation ordinarily aims to replace two-thirds of the lost wage, but, in fact, the amount is usually less[146]; chronic disease is not ordinarily compensated[147]; and indirect subsidies are provided by other taxpayers (because benefits are generally not taxable) and by state and federal support of administrative and rehabilitation costs. Insurance pooling, by definition, further reduces costs to employers and therefore reduces incentives to deter pollution.

Social Security disability insurance has no effect on preventing pollution because by law[148] insurance premiums are to be paid by each employer and employee regardless of the actions that they may take to avoid disease or injury and regardless of the extent of the occupational risk. The goal of the SSDI is to provide disability insurance.

In theory, the courts provide a disincentive to harmful conduct. In accident cases and other situations in which cause is easily identifiable, the relative certainty of timely recovery and large award

Table 5–8

Sources of Income for Severely Disabled Adults Ages 20–64, 1972 and 1974

Year	Causes			
	All	Job related		
		Injuries	Disease	Total
1972				
Number of severely disabled (millions)	5.0	0.2	0.6	0.8
Source of support (percentage)				
Social Security	37	50	44	45
Workers' compensation	4	43	3	14
Public welfare	22	14	22	19
Pensions	15	18	19	18
Veterans' benefits	13	21	13	15
Private insurance	2	2	1	2
1974				
Number of severely disabled (millions)	5.6	0.4	0.7	1.1
Source of support (percentage)				
Social Security	48	38	53	47
Workers' compensation	2	15	5	9
Public welfare	22	16	16	16
Pensions	14	17	21	20
Veterans' benefits	12	4	17	12
Private insurance	1	NA	1	NA

NA = Not available.

Source: U.S. Department of Labor, "An Interim Report to Congress on Occupational Diseases," June 1980, p. 61.

may modify behavior. But bringing suit has been severely criticized because of delays and transaction costs (particularly attorneys' fees).[149] In chronic disease cases involving environmental pollution, the problems are much worse. The costs of scientific studies needed to prove a case may well be beyond the value of the case and will therefore add to the pressure on injured parties to settle.

Procedural devices such as statutes of limitations may operate to bar a suit.[150] Because cancer and possibly other diseases have long latencies, compensation cases may not be brought until 20, 30, or more years after exposure. Whatever economic incentive may be provided by the possibility of large recoveries in the tort system, it is surely dissipated when discounted over many years. Because the injured party ordinarily bears the burden of proof as to causation and, in the absence of such data, cannot win, the tort system may also take away incentives for companies to conduct research on the effects of environmental contaminants. In some cases, a polluter's lack of knowledge may excuse liability. Thus it would appear that, except perhaps when cause and effect are easily demonstrated, the tort system probably has little effect on deterring pollution.

The 1973 PBB contamination case in Michigan is an example of the difficulties of tort litigation of toxic substance pollution.[151] Farmers whose livestock was contaminated by grain contaminated with PBB sued Michigan Chemical Co. (the PBB manufacturer), Farm Bureau Services, Inc. (the feed manufacturer), Falmouth Co-op Company (seller of the contaminated feed), and others. The trial lasted 14 months; it was the longest in Michigan history. The farmers sought compensation for destruction of their cattle, loss of earnings, and other damages. The decision, in 1978, went against the farmers. Although they had suffered economic damages, they could not prove that PBB had caused adverse health effects in their animals. The time, expense, and effort involved in the asbestos cases are comparable to the PBB case, although there have been substantial recoveries in several.[152]

Other Approaches

In Europe, occupational and environmental diseases are generally treated as part of national health and welfare insurance programs. A few countries have specific laws to compensate victims of environmentally caused diseases.

A 1973 Japanese law established an administrative structure to oversee compensation payments to victims of specified pollution-related diseases.[153] Victims of designated diseases arising in officially identified pollution areas are examined by a special Health Damage Certification Council comprised of medical, legal, and other experts. Upon certification, victims are eligible for reimbursement of medical expenses and lost earnings. Assistance is also provided to survivors for funeral and other expenses.

Under the Japanese law, polluters pay. For example, revenues for compensation of air pollution-induced diseases in particular areas are derived principally from a graduated emissions charge and secondarily from a tonnage tax on automobiles. Companies must also make direct compensation payments to the victim for diseases traceable to a specific substance. From 1973 to mid-1978, between $600 million and $1 billion was collected to compensate some 58,000 victims.[154]

Recent efforts to compensate U.S. victims of pollution have received widespread attention. The Toxic Substance Pollution Victim Compensation Act,[155] introduced in 1977, represented a far-reaching attempt to modify tort principles and provide a new mechanism for compensation. The Act would establish an independent administrative agency to adjudicate technical and scientific issues. It would determine who would be eligible for compensation, the amount of the award, and the party responsible for paying the award. The manufacturer, processor, distributor, or disposer of the substance held responsible for the disease would be required to pay the full amount of any awards. Under the bill, there would also be significant modification in state tort law which would facilitate recovery in pollution cases. The bill focused attention on compensation problems

of victims, but because of numerous technical difficulties, it did not receive much support. The Congress has not acted on the bill.

In 1979, the President proposed the Oil, Hazardous Substances, and Hazardous Waste Liability and Response Act[156] as a means of cleaning up oil and hazardous substance spills and waste dumps and of providing limited compensation for economic loss from such spills. The bill would establish a $1.6 billion fund for this purpose. (The status of the legislation is discussed in an earlier section on hazardous wastes.) The Environmental Emergency Response Act (the Muskie-Culver bill),[157] introduced in 1979, had similar goals. The Administration bill would provide compensation for some economic damages; the Culver-Muskie bill would allow compensation for a wide range of personal injury and economic damages and would create a private cause of action to sue a polluter in federal court for damages from spills and hazardous waste dumpsites. An injured person could sue the polluter directly or seek compensation from a fund established by the bill. To recover what it paid out, the fund would sue the polluter. Changes in the bill limit coverage for personal injury to those arising within 6 years of exposure.

Individuals who believe that they were injured by pollution can be expected to continue their efforts to obtain compensation in court. However, because of the rigorous proof standards, many additional efforts will probably focus on government programs.

Clearly more research and debate are needed on these questions. The Department of Labor is reviewing three alternatives—changes in worker compensation, changes in Social Security disability coupled with supplemental payments for occupational disease, and programs related to single diseases, e.g., asbestosis, brown lung.[158] Recently the National Science Foundation initiated a study of victim compensation programs. A mandate for the Congressional Office of Technology Assessment to conduct a more expansive compensation study is contained in the pending House reauthorization of the Toxic Substances Control Act.[159]

TRADE SECRETS

In the regulation of toxic chemicals, treatment of trade secrets has emerged in the mid-1970s as a major problem. It is generally recognized that businesses have legitimate interests in keeping some information secret from competitors. If a company spends a large amount of time and money developing a new product—a new formula for shampoo, for example—and develops a superior item, one way to benefit is to keep the shampoo formula and performance data secret from competitors. Federal laws generally protect the rights of businesses to keep such information secret on the grounds that secrecy will foster innovation and competition.

The protection of trade secrets concerning toxic substances creates potential problems. For example, from 1972 to 1974, the National

Institute for Occupational Safety and Health attempted to characterize chemicals to which a potentially wide cross section of U.S. workers are exposed on the job. The survey identified approximately 86,000 unique products from 10,000 manufacturers.[160] For 75 percent of the potential exposures, neither the workers nor the manufacturers using the products knew the products' chemical identities.[161] Products were identifiable by their trade names only, and their exact chemistry, in followup requests by the National Institute for Occupational Safety and Health to the product manufacturers, was claimed to be a trade secret in more than 35 percent of the cases.[162] Under such circumstances, it is extremely difficult for anyone—regulator, manufacturer, or worker—to make intelligent decisions about health and safety risks and precautionary measures.

Protection of trade secrets affects the labeling and regulation of consumer products, of pesticides, and of food additives as well as of industrial chemicals. Even if, as is the case under most laws, the government has access to trade secret data (formulas, health and environmental effects studies, process information) in order to establish regulations, protecting trade secrets from general disclosure severely limits the public's ability to participate in regulatory decisions and to make informed choices about where to work or what products to use. Medical and scientific research is also impaired by data confidentiality. It becomes difficult to look for patterns of disease in selected groups of people exposed to a particular substance if few of them know the identity of substances to which they have been exposed. A company's testing of health effects may not be subject to the scrutiny of the general scientific community if the tests are not made public, with the result that errors in test methods or data are not detected. Research may be needlessly duplicated and scientific advancement slowed.

Health and Safety Data

Public disclosure of health, safety, and efficacy data on drugs and chemicals is a controversial issue. The laws regulating pesticides and drugs, for example, require manufacturers to provide health, safety study, and other data to government agencies which must evaluate the risks of the products before they can be sold. Studies are sometimes costly and may take years to complete (see the discussion on testing in the following section). If competitors can obtain the test protocols and results without paying for them and can duplicate the tests without the costs and delay of trial and error or can use the results to register their own products, the originating firm may be at a competitive disadvantage. Yet if such data are not made public, it is extremely difficult to conduct an effective review of them or to have public participation in regulatory proceedings.

Sometimes, but not always, a patent can be used to protect a company's product from competition. Companies often choose not to patent a product because the information that would be made public

might enable a competitor to make a similar and equally saleable version of the original product.

Two recent statutes, the Toxic Substances Control Act of 1976[163] and the 1978 amendments to the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA),[164] have resolved the question in favor of greater public disclosure. In some situations, FIFRA grants manufacturers the exclusive use of health, safety, and efficacy data submitted to the government. For a prescribed period, no one else can use the data to register a pesticide without the permission of the company that submitted the data. In other situations, the manufacturer is guaranteed the right to payment for use of the data by any new registrant.[165] The TSCA grants similar rights to compensation but does not provide for a period of exclusive use.[166] Neither statute has been in effect long enough to know how it will work in practice.

The Toxic Substances Strategy Committee (TSSC) considered the trade secret issue.[167] To increase legitimate public access to confidential data, it recommended that agencies operating under statutes that do not permit disclosure of confidential health, safety, and efficacy data in raw form release detailed summaries of such data. Summaries may provide desired information in many instances, but they are not always sufficient. Without the raw data, individuals with a legitimate interest in reviewing them—for example, a public interest group or a scientist studying the health hazards of a chemical —would be unable to analyze study methods and conclusions adequately. The TSSC also recommended that agencies be given statutory authority to release health, safety, and efficacy data in raw form, under appropriate safeguards, to selected persons or groups who satisfy a "good cause" public interest standard. This recommendation would permit limited public disclosure of data to fulfill a legitimate public need—participation in a regulatory proceeding, for example—while preventing disclosure to competitors.

International Initiatives

The question of trade secrets is currently being considered by the Organization for Economic Cooperation and Development (OECD). In May 1980, a meeting of high-level officials strongly endorsed the work of the Expert Group on Confidentiality, which began in 1979 under the leadership of France. The Group is attempting to develop principles which would allow governments to exchange health and safety data but to safeguard data confidentiality.[168]

TESTING UNDER THE TSCA

Encouragement of more, better, and earlier testing of chemicals for possible adverse effects on human health and the environment was a driving force behind passage of the Toxic Substances Control

Act of 1976. Yet 4 years later, it is the complex testing issues that are a significant obstacle to timely implementation of the Act.

The TSCA gives EPA broad regulatory authority over chemical substances during all phases of their life cycles—from prior to their manufacture to disposal. It directs EPA to inventory the approximately 55,000 [169] chemical substances in commerce, to require premanufacture notice to EPA of all new chemical substances, and to enforce recordkeeping, testing, and reporting requirements so that EPA can assess the relative risks of chemicals and regulate them.

In the opinion of many observers, implementation of the TSCA has been extremely slow. As of July 1980, only five classes of chemicals—PCBs, chlorofluorocarbons, phthalate esters, chlorinated benzenes, and chloromethane—have been subject to any regulatory action at all. EPA officials view the slowness as disappointing but understandable, considering the need to hire and train staff, the unfolding realization of the number and variety of chemicals to be screened and evaluated and of deficiencies in knowledge about them, and the importance of thorough and detailed review of the complex social, economic, scientific, and technological problems involved in establishing regulations. Environmentalists regard the slowness as unnecessary and potentially damaging to the nation. They argue that EPA is overly cautious and conservative and is more concerned with administrative perfection and accommodation of all viewpoints than with legislative intent and public expectations for controlling chemical risks. Industry, on the other hand, believes that in some cases EPA has moved too rapidly, in that it has proposed and promulgated rules without thorough examination of all issues and economic impacts.

A key question for EPA is how to use TSCA's many interrelated testing and reporting provisions to set priorities and to screen, evaluate, and control chemical substances presenting unreasonable risks. Ideally, EPA would ensure a balance between focusing attention and resources on a very few chemicals whose effects are known to be severe and giving sufficient attention to the tens of thousands of chemicals whose risks are not known. The process of developing strategies is most controversial for EPA.

Testing Guidelines for New Chemicals

Although the TSCA does not require routine testing of all new chemicals before they are produced or marketed, it clearly requires more than simple notification to EPA of the intent to manufacture a new chemical. At least 90 days before manufacturing or importing a new chemical, a firm must submit test results or other information to EPA showing that the chemical will not present "an unreasonable risk" of injury to health or the environment.[170] On the basis of these premanufacture notifications (PMNs), EPA may limit manufacture, use, or disposal.

EPA's early experience with TSCA's premanufacture review proc-

ess, which went into effect in July 1979, indicates that industry is not providing sufficient data for determining risk. Many notices lacked information on product uses and exposure. Even more troublesome was the fact that more than one-half the PMNs submitted in the first year contained no health or environmental effects test data whatsoever, and almost none included any studies of chronic or subchronic health effects.[171]

Because of the short period provided for EPA review and the sparsity of the information that has been submitted, EPA plans to issue guidelines on the type of information that it needs for premanufacture evaluation. EPA is expected to propose the first such guidelines in the fall of 1980. Although some small companies and a few large ones favor detailed PMN guidance, most companies and trade associations have urged that the guidelines be general and flexible, with the nature and extent of testing left to the discretion of the company.

A basic question to be answered is whether the testing guidelines should reflect a sequential, tiered approach consistent with that being developed internationally by the OECD Chemicals Testing Program. (The test protocols are discussed in the section that follows.) In a tiered approach, a battery of relatively simple tests is used to screen chemicals for adverse health and environmental effects; the results are used to determine whether complex, extensive, longer-term tests should be undertaken.

This approach is desirable in terms of using testing resources efficiently. But its effectiveness depends on the existence of scientifically valid tests for each health and environmental effect to be assessed—e.g., carcinogenicity, mutagenicity, behavioral effects, acute toxicity, persistence, and biodegradation. The tests must be practical in terms of costs, availability of trained personnel, equipment, and facilities. Descriptions of the tests and their results should also be standardized.

Dependable and uniform test methodologies exist for some but not all the effects to be tested. The state of the art is somewhat more advanced for long-term tests and is less reliable and uniform for initial screening and midlevel confirmatory tests. In addition, scientists do not agree on the results of initial tests that indicate the need for further testing.

Given these problems, EPA will probably propose the OECD testing guidelines for new chemicals which are the initial step in a tiered approach; they set minimum tests to be performed on all new chemicals.[172]

Whether the testing guidelines will provide more helpful information to EPA is not clear because, to a large extent, the TSCA places the burden of proof on EPA to show that a new chemical would present an unreasonable risk, rather than on industry to show that it would not. Thus some question exists about what incentive industry has to cooperate fully with the guidelines. There

is also the very practical consideration that EPA—because it cannot predict how many PMNs it will receive at any one time—cannot plan its workload. An early estimate of 400 PMNs to be processed per year may be low. Crucial questions then become how to streamline the review in order to focus on the new chemicals with the greatest potential risks and how to persuade industry to cooperate in the review.

In March 1980, it was widely reported that EPA would change its internal review process to create a fast track for chemicals which are of little concern or can be reviewed quickly. EPA is also examining other alternatives, including the issuance of "significant new use rules," an authority granted by the TSCA [173] but so far not invoked. If a chemical is to be produced in larger quantities or for different uses than were initially proposed in the PMN, the producer should be required to submit a new PMN. This procedure would allow EPA to delay its detailed review until the chemical is scheduled for production in significant quantities. EPA expects to begin issuing significant new use rules in 1981.

EPA also has authority under the TSCA to issue temporary restrictions on a chemical pending development of needed information.[174] In April 1980,[175] EPA proposed prohibition of the manufacture of six phthalate esters—new plasticizers for which no test data were provided but which, given the known effects of related chemicals, could pose a cancer risk to workers and cause fish kills in effluents discharged by the manufacturers. EPA's proposal prompted the manufacturer to withdraw the PMNs. EPA action on phthalate esters escalated the controversy over whether this provision of the TSCA was intended to be invoked only in very exceptional circumstances of predicted high exposure or unreasonable risk or whether it was intended to be invoked more broadly, e.g., whenever PMN submissions are inadequate.

Still another way for EPA to handle the problem of inadequate data in PMNs would be to issue a test rule requiring industry to test both the new substance and similar chemicals. In addition to ensuring that adequate test data are received on the proposed new chemical, this strategy would make regulation consistent—new chemicals would not be subject to more stringent regulatory action than existing chemicals that are similar.

Test Rules

By formal rulemaking, under certain conditions EPA may require industry to test chemicals which may pose "an unreasonable risk" to human health or the environment.[176] Although some test rules will originate with premanufacture review, most will be developed for one or a group of *existing* chemical substances. In July 1980, EPA proposed rules for testing chloromethane and chlorinated benzenes.[177]

EPA efforts to develop policies for issuing test rules have been controversial. Disagreement has centered on how chemicals are selected for testing, how detailed an evaluation must precede issuance of a test rule, and what kinds of tests should be conducted by whom.

Under the TSCA, EPA may promulgate test rules for any chemical or category of chemical substances or mixtures for which there are insufficient data available to judge the risks posed by the chemical(s) and testing is needed to develop the data or which is (are) produced in substantial quantities and extensive human or environmental exposure is anticipated. The statute does not say how broad a category may be, except to prohibit "all new chemicals" as a testing category.

The principal, though not the only, source of candidates for test rules is the priority list developed by the Interagency Testing Committee (ITC) which the TSCA established. The priority list, to be revised semi-annually, may not include more than 50 chemicals or categories of chemicals at one time. After this maximum is reached, additional chemicals may be designated only as earlier recommendations are acted upon by EPA. By law, within 12 months of a chemical's inclusion on the list, the EPA Administrator is to begin proceedings for a test rule or to publish the reasons for failing to do so in the *Federal Register*.[178]

It is EPA's intention to consider non-ITC chemicals for test rules, including substances that fall partially under other laws but whose potentially serious hazards are not being considered—either because the relevant law does not provide authority to require testing or for administrative reasons. These candidates might include high-exposure occupational and consumer hazards, drinking water additives, and inert pesticide ingredients. In addition, EPA's own staff assessments, evaluations of petitions from outside groups, and information received as a result of the TSCA's reporting requirements could produce other candidates for test rules.

As of mid-1979, EPA had not developed test rules either for the 38 chemicals and groups of chemicals recommended by the ITC[179] or for any other substances. In May 1979, the Natural Resources Defense Council sued EPA for failing to meet the statutory deadline.[180] In February 1980, the court ruled that the Agency had violated the TSCA and required it to submit a schedule for test rule development.[181]

In EPA's affidavit filed in March 1980, the Agency explained its administrative and policy difficulties and set a schedule for 21 chemicals and chemical groups for which the 12-month deadline had passed. The schedule extends to spring 1984 for proposed rules and/or *Federal Register* notices. The affidavit details the process of information gathering, analysis, decisionmaking, and test rule development and states that EPA can handle an estimated 15–20 chemicals per year. EPA does not expect to be able to publish pro-

posed rules within 12 months of the ITC recommendations, but it will try to publish an Advance Notice of Proposed Rulemaking within that time for information purposes and to solicit public comment. EPA has estimated direct contract costs to gather the data necessary to issue a legally supportable rule at $130,000–$240,000 per chemical or chemical group. If these costs are added to internal costs, the total spent in issuing some test rules may exceed industry's costs of conducting the required testing.[182]

As reasons for missing its statutory deadlines, EPA listed problems in staffing the new office, inexperience of new employees with the rulemaking process, gross underestimation of the number and complexity of the issues, and the time spent in resolving one-time issues.

Some of the problems relate to circumstances under which test rules for categories of chemical substances and mixtures are appropriate. The initial ITC list of 38 priority substances for testing included 23 individual chemicals and 15 chemical groups. Some of these groups are by definition closed categories—that is, they contain a finite number of specified chemicals. Others are open ended, including many existing chemicals plus others that may be manufactured in the future. For example, the closed category of mono- and di-chlorinated benzenes includes only 4 chemicals; the open-ended category of aryl phosphates includes about 300 identified existing members, and the number is expected to grow.

In general, industry has opposed use of broad categories, citing the costs of testing multiple chemicals, the bad reputation that "innocent" members of a category might acquire because of test rules for the category, and the inability to introduce new chemicals in a category during the testing period.[183]

Nevertheless, EPA will probably move in this direction, believing that the TSCA definition of "category" [184] is purposely very broad and that testing by individual chemical would be extremely slow. EPA believes that this approach is reasonable because a specific chemical does not present an absolutely unique risk but produces effects similar to those of chemicals that it resembles.[185] In addition, regulating by category is considered an important way of avoiding a shift in production or use away from a substance receiving regulatory attention to similar substances that may pose even greater hazards.

There is also the question of how much research and justification EPA must provide for a test rule. Industry and EPA appeared to agree that under the law EPA must provide extensive justification for issuing test rules and that the burden of proof is primarily on the Agency to determine whether a chemical may present an unreasonable risk and thus require further testing. For the first 38 chemicals on the ITC list, EPA conducted an exhaustive literature review, including some foreign sources requiring translation and scientific studies from earlier decades. For its review of toluene, for

example, EPA had received 5,440 abstracted and 1,106 hard-copy scientific studies by February 1980. They represent only part of the information gathering and analysis effort for that chemical.[186]

Environmental groups maintain that a far less detailed and time-consuming review would be compatible with legislative intent. They insist that the burden of proof should rest on industry to dispute an EPA claim that a chemical or chemical category meets the statutory criteria for a test rule.

In addition to issuing test rules that indicate which chemicals are to be tested, EPA is instructed by the TSCA to issue generic "test standards" which will address methodological and other issues such as test conditions and reporting of results. Laboratory standards have been proposed for health effects and general performance, and 18 specific standards were also proposed for the conduct of tests for cancer and other oncogenetic effects, other chronic toxicity, combined chronic effects, acute effects, subchronic effects, mutagenicity, teratogenicity, reproductive effects, and metabolic effects.[187] Standards for neurotoxicity testing, behavioral teratogenicity testing, and additional metabolic and mutagenicity tests will be proposed later; the first of 62 environmental fate and ecological effects and physical and chemical property test standards are scheduled to be proposed in late 1980. Laboratory practice standards on ecological effects testing will also be proposed this year.

The nature of the test standards has been a matter of considerable debate, with most industry representatives favoring very broad voluntary guidelines and a few companies preferring detailed guidance from EPA. The international test guidelines being developed by OECD on new chemicals and those being developed by the Interagency Regulatory Group (IRLG) to provide uniformity among U.S. regulatory agencies are broader than EPA's test standards. EPA is participating in IRLG and OECD efforts and is willing to use their guidelines, but it reserves the right to require more detailed or different test protocols and additional tests should it believe circumstances warrant.

When EPA issues a test rule, the TSCA requires that it specify what kinds of toxic effects must be tested for. Industry favors requiring a minimum, preferably short-term screening tests that are not costly. The ITC has recommended more thorough testing, including long-term whole animal tests for chronic toxicity and carcinogenicity and epidemiological studies of large groups of people who have been exposed. But the ITC, in recommending tests to EPA, has considered the possible adverse effects of a chemical. EPA is considering a broader view, recognizing that testing for one type of effect is often relevant to evaluation of another. It is likely that EPA will move in the direction of tiered testing.

Once a test rule is promulgated, it applies to all manufacturers, importers, and processors. To avoid duplicate testing by many companies, the TSCA permits EPA to exempt a manufacturer or

processor of a chemical that is "equivalent" to one for which testing is required. The firm then shares the cost with those who are doing the testing.

Working out the details of exemption and reimbursement policies has been difficult, but EPA and industry agree that the policies should be as simple and objective as possible and should require only minimum government involvement. Voluntary industry arrangements for cost allocation and identity of the company, consortium of companies, trade association, or third party to be responsible for testing are being sought.

EPA invited industry advice. The Chemical Manufacturing Association (CMA) proposal raised many questions—how and when "equivalent" is to be defined, under what circumstances exemptions may be revoked, how exemptions are applied to new chemicals, how a company's "market share" should be determined so that test costs can be fairly allocated, what should be included in an official rule rather than in informal voluntary arrangements, how reimbursement disputes should be settled, and how confidential information can be protected in communications concerning what company shall test chemicals and how test costs are to be allocated.

The Natural Resources Defense Council did not find EPA's court-ordered schedule for test rule development acceptable and filed lengthy interrogatories asking EPA for further information on its literature search and data evaluation. The CMA also disagreed with the EPA approach, calling, on the one hand, for quick decisions on whether a chemical should be tested but, on the other, for an even longer time for development of a test rule that EPA proposed.

Regardless of the outcome of the NRDC suit, EPA is not satisfied with its timetable and test rule development process. Among the options for addressing the issues, EPA is considering or is being urged to consider:

- More thorough work by the ITC before it recommends chemicals to EPA.
- Required testing for only some effects for which additional information would be desirable. This limitation would reduce the time and costs of preparing test rules as well as the costs of testing. If the chemicals were found to pose unreasonable risk for the effects tested, then regulation of the chemical would presumably reduce exposure to such an extent that risks from other effects would also be reduced or eliminated.
- More frequent use of broad categories of chemical substances, based on chemical structure, with a sampling approach to the selection of particular category members for testing.
- Issuance of very broad generic test rules based on considerations other than chemical structure, for example, all chemicals with a common use, common physical and chemical properties, and common production levels.

- Substantially less exhaustive literature searches and other analyses to justify a test rule, perhaps coupled with a legislative amendment that explicitly places the burden of proof on industry to show why a proposed test rule is inappropriate.

Reporting Provisions

Section 8(a) of the TSCA allows EPA to require industry to provide information on chemical identity and structure, uses, volume manufactured or processed, byproducts, expected exposures, disposal, and "all existing data concerning the environmental and health effects of such substance or mixture." [188]

EPA issued its first request under Section 8 in February 1980,[189] asking for information on production volume, environmental release, and worker exposure for 2,300 chemicals. EPA planned to issue two later requests which would apply to fewer chemicals and would provide progressively more detailed information in order to continue the process of risk assessment.

The CMA petitioned EPA to adopt a completely opposite approach,[190] insisting that a detailed dossier be prepared for every substance to meet EPA's information needs. With that, EPA would either have to engage in a lengthy rulemaking process to justify its need for each piece of information requested, to try to convince industry to submit the information voluntarily, or to ask for very minimal information, review it, and then request further information.

The CMA petition was totally unacceptable to EPA because it would require EPA to have in advance the very information on a chemical that it was seeking to obtain through the reporting rule. As of July 1980, the impasse had not been resolved.

The EPA proposal to implement TSCA provisions for industry submission of unpublished health and safety studies [191] was also attacked by the CMA. The CMA disagreed with EPA on the extent of the information requested, the definition of a health and safety study, the criteria for selecting chemicals to which the requirement should apply, the definition of which persons are subject to reporting, the protection of confidential information, and the plan to require such information for all ITC-recommended chemicals.

Full implementation of TSCA will not be possible until these issues are resolved. Some are near resolution, but because many provisions of the law are interrelated, overall progress is not expected to be smooth or rapid. Some degree of Congressional involvement is likely, perhaps by amendments that clarify policy and procedures but do not change the basic objectives of the TSCA.

EXPORT POLICY FOR HAZARDOUS SUBSTANCES

In 1977, the sale of more than 2 million pairs of TRIS-treated

children's pajamas abroad focused U.S. and international attention on the problem of "dumping" stringently regulated U.S. products abroad. Pajamas treated with TRIS (tris(2,3-dibromopropyl) phosphate) were banned from the U.S. market after this flame retardant was determined to be a carcinogen.[192] After the dumping, some of the less developed nations requested that the UN Environment Programme ask nations not to export hazardous substances without the knowledge and consent of the importing nation.[193] Further, the Congress held hearings on hazardous exports in 1978.[194]

An Ad Hoc Working Group consisting of 24 federal agencies was convened to consider federal policy on export of hazardous substances. The Group has held numerous meetings and working sessions and has consulted extensively with representatives of the chemical, pesticide, consumer product, and pharmaceutical industries and with consumer, environmental, health, and labor organizations.

The issues are highly complex, with existing laws and regulations varying from one type of regulated substance to another. Legal requirements range from a total ban on the export of some hazardous substances to an absence of any restriction for others.

In 1978, the Congress amended consumer protection and pesticide regulation laws to require that importing countries be notified of shipment of certain products banned in the United States.[195] Early in 1980, amendments were proposed to require that export controls be placed on all substances and products whose manufacture, sale, use, or disposal is prohibited or severely restricted in the United States.[196]

In June 1980, the Council on Environmental Quality testified on behalf of the Ad Hoc Working Group at hearings on the proposed amendments;[197] the Group concluded that, in most circumstances, the international responsibilities of the United States could be met by an effective hazard notification system. It recommended that the notification procedures adopted by the Congress in 1978 be made more uniform by channeling them through the State Department and that a summary of all U.S. regulatory actions which ban or significantly restrict hazardous substances for domestic use be published annually. The summary would be given to foreign governments and other interested parties.

For a limited number of hazardous substances, the Working Group argued, more than notification is needed. Export of some very hazardous banned substances and products could pose serious foreign policy problems for the United States, engendering distrust and undermining confidence in U.S. exports. The Working Group proposed that the export of this limited group be controlled under existing authority of the Export Administration Act.[198] An interagency task force would advise the State Department on the substances that should be subject to export controls. The State Department would then make recommendations to the Commerce De-

partment on export controls for these substances. Exports of controlled substances would be allowed on a case-by-case basis, provided that the State Department found the shipment not to be injurious to U.S. foreign policy interests and the importing nation had no objection.

The Group also agreed that the United States should participate in and strongly support international efforts to bring about control of hazardous exports from other nations and to assist less developed countries in evaluating hazardous products. As of July 1980, the Working Group was seeking additional public comment on and was refining its proposals.

REFERENCES

1. Federation of American Societies for Experimental Biology, *Evaluation of the Health Aspects of Caffeine as a Food Ingredient*, SCOGS–89 (Washington, D.C.: U.S. Food and Drug Administration, 1978), p. 36.
2. Toxic Substances Strategy Committee, *Toxic Chemicals and Public Protection* (Washington, D.C.: U.S. Government Printing Office, 1980).
3. *Id.* p. 148.
4. Susan S. Devesa and Debra T. Silverman, "Cancer Incidence and Mortality Trends in the United States: 1935–74," *Journal of the National Cancer Institute* 60:545–71 (1978).
5. Earl S. Pollack and John W. Horm, "Trends in Cancer Incidence and Mortality in the United States 1969–76," *Journal of the National Cancer Institute* 64:1091 (1980).
6. Toxic Substances Strategy Committee, *supra* note 2, at 116–66.
7. Susan S. Devesa and Debra T. Silverman, *supra* note 4, at 550. Although strictly equivalent rates for blacks are not readily available, it is known that the increase in black male deaths was more than double that for white males from 1950 to 1977. At the same time, cancer deaths in both white and black women decreased; the decrease for black women was about one-half that for white women. Lawrence Garfinkel, Cyril E. Poindexter, and Edwin Silverberg, "Cancer in Black Americans," *Ca–A Cancer Journal for Clinicians* 30(1):39–44 (1980).
8. Earl S. Pollack and John W. Horm, *supra* note 5, at 1101.
9. *Id.* p. 1095.
10. *Id.* p. 1096.
11. Toxic Substances Strategy Committee, *supra* note 2, at 160–66.
12. James E. Enstrom, "Rising Lung Cancer Mortality among Non-Smokers," *Journal of the National Cancer Institute* 62:755 (1979).
13. Toxic Substances Strategy Committee, *supra* note 2, pp. 160–66.
14. International Trade Commission, "Synthetic Organic Chemicals: United States Production and Sales, 1920–1977," cited in Devra Lee Davis and Brian H. Magee, "Cancer and Industrial Chemical Production," *Science* 206:1356 (1979).
15. Devra Lee Davis and Brian H. Magee, *supra* note 14, at 1356–58; Robert Hoover, "Environmental Cancer," *Annals of the New York Academy of Sciences* 329:50–60 (1979).

16. U.S. Department of Health, Education, and Welfare, *The Federal Coal Mine Health Program in 1973* (Washington, D.C.: U.S. Government Printing Office, 1975).
17. Robert Berkow, ed., *The Merck Manual of Diagnosis and Therapy* (Rahway, N.J.: Merck, Sharp and Dohme Research Laboratories, 1977), p. 588.
18. H.A. Kahn, "The Dorn Study of Smoking and Mortality among U.S. Veterans: Report on 8½ Years of Observation," in W. Haenszel, ed., *Epidemiological Approaches to the Study of Cancer and Other Chronic Diseases,* National Cancer Institute Monograph 19 (Washington, D.C.: U.S. Government Printing Office, 1966), pp. 1–125, cited in U.S. Department of Health, Education, and Welfare, *Smoking and Health* (Washington, D.C.: U.S. Government Printing Office, 1979), p. 5–64.
19. J.P. Wyatt, "Environmental Factors in Chronic Lung Disease," in D.H.K. Lee, ed., *Environmental Factors in Respiratory Disease,* Fogarty International Center Proceedings No. 11 (New York: Academic Press, 1972), pp. 119–37, cited in U.S. Department of Health, Education, and Welfare, *supra* note 18, at 6–52.
20. P.M. Lambert and D.D. Reid, "Smoking, Air Pollution and Bronchitis in Britain," *Lancet* 1:853–57 (1970).
21. Jeanne M. Manson and Ruth Simons, "Influence of Environmental Agents on Male Reproductive Failure," in Vilma R. Hunt, *Work and the Health of Women* (Boca Raton, Fla.: CRC Press, 1979), p. 155.
22. Frederick David Abramson, "Spontaneous Fetal Death in Man," *Social Biology* 20:375–403 (1973).
23. Dwight T. Janerich, "Environmental Hazards and Birth Defects," *Annals of the New York Academy of Sciences* 329:10–13 (1979).
24. W.B. McBride, "Thalidomide and Congenital Abnormalities," letter, *Lancet* 2:1358 (1961).
25. W.B. Gill, Gebhard F.B. Schumacher, and Marluce Bibbo, "Structural and Functional Abnormalities in the Sex Organs of Male Offspring of Mothers Treated with Diethylstilbestrol (DES)," *Journal of Reproductive Medicine* 16:147–53 (1976); Arthur L. Herbst, Stanley J. Robboy, Robert E. Scully, and David C. Poskanzer, "Clear-Cell Adenocarcinoma of the Vagina and Cervix in Girls: Analysis of 170 Registry Cases," *American Journal of Obstetrics and Gynecology* 119:713–24 (1974).
26. Dwight T. Janerich, "Epidemic Waves in the Prevalence of Anencephaly and Spina Bifida in New York State," *Teratology* 8:253–56 (1973).
27. Brian MacMahon and Stella Yen, "Unrecognized Epidemic of Anencephaly and Spina Bifida," *Lancet* 1:31–33 (1971).
28. J.A. Thomas, "Effects of Pesticides on Reproduction," in J.A. Thomas and R.L. Singhal, eds., *Advances in Sex Hormone Research,* Vol. 1 (Baltimore: University Park Press, 1975), pp. 205–223.
29. Vilma R. Hunt, *supra* note 21, at 201–204.
30. "A Test for Women's Job Rights," *Chemical Week,* March 1980, p. 58.
31. *Christman et al.* v. *American Cyanamid Co.*, No. 80–0024–P (N.D. W.Va., filed January 28, 1980).
32. Rebecca L. Rawls, "Reproductive Hazards in the Workplace," *Chemical and Engineering News,* February 11, 1980, p. 30.
33. *Id.* p. 29.
34. Charles Dickens, *The Uncommercial Traveller—All Year Round,* New Series 1(13) and 25 (London: Chapman and Hall, 1861).
35. Robert Berkow, *supra* note 17, at 1070.
36. T.J. Chow, J.L. Earl, and C.B. Snyder, "Lead Aerosol Baseline: Concentration at White Mountain and Laguna Mountain, California,"

Science 178:401–402 (1972), cited in D.M. Settle and C.C. Patterson, "Lead in Albacore: Guide to Lead Pollution in Americans," *Science* 207:1167–76 (1980); id. p. 1170.

37. 43 Fed. Reg. 46247 (1978).
38. 40 C.F.R. 80.20, 40 C.F.R. 80, 41 Fed. Reg. 42675 (1976).
39. 44 Fed. Reg. 33116 (1979).
40. D.M. Settle and C.C. Patterson, *supra* note 36, at 1173; B. Schaule, thesis, University of Heidelberg, West Germany, 1979.
41. Information provided by K.R. Mahaffey, Division of Nutrition, U.S. Food and Drug Administration, Cincinnati.
42. 44 Fed. Reg. 51233 (1979).
43. H.L. Needleman et al., "Deficits in Psychologic and Classroom Performance of Children with Elevated Dentine Lead Levels," *New England Journal of Medicine* 300:689–95 (1979); J.S. Lin-fu, "Lead Exposure among Children—A Reassessment," *id.* pp. 731–32.
44. R.G. Lansdowne et al., "Blood-Lead Levels, Behavior, and Intelligence: A Population Study," *Lancet* 1:538–41 (1974), cited in H.L. Needleman et al., *supra* note 43.
45. Irwin H. Billick, Anita S. Curran, and Douglas R. Shier, "Analysis of Pediatric Blood Lead Levels in New York City for 1970–1976," *Environmental Health Perspectives* 31:183–90 (1979).
46. U.S. Department of Health, Education, and Welfare, Center for Disease Control, *Preventing Lead Poisoning in Young Children*, 00–2629 (Atlanta, 1978), cited in National Academy of Sciences, Committee on Lead in the Human Environment, *Lead in the Human Environment* (Washington, D.C., 1980), p. 63.
47. K.R. Mahaffey et al., "Preliminary Analysis of Blood Lead Concentrations: HANES II, 1976–1978," presented at the 13th Annual Conference on Trace Substances in Environmental Health, Columbia, Mo., June 1979.
48. Lead-Based Paint Elimination Act of 1971, 42 U.S.C. §§4801–4846.
49. Irwin H. Billick and V. Eugene Gray, *Lead Based Paint Poisoning Research: Review and Evaluation, 1971–1977* (Washington, D.C.: U.S. Government Printing Office, 1978), Table 2–1, p. 12.
50. National Academy of Sciences, *supra* note 46.
51. 21 C.F.R. § 182 (1979).
52. Federation of American Societies for Experimental Biology, *supra* note 1.
53. Kenneth R. Hirsh, Marilyn G. Pinzone, and Jesse H. Forde, "Spontaneous Locomotor Activity Changes Evoked by Caffeine in Mice," *Federation Proceedings* 33:466 (1974).
54. A.W. Burg, testimony, Federation of American Societies for Experimental Biology, Select Committee on GRAS Substances, public hearings on caffeine, September 26, 1977, cited in Federation of American Societies for Experimental Biology, *supra* note 1, at p. 7.
55. William Revelle, Phyllis Amaral, and Susan Turriff, "Introversion/Extroversion Time Stress and Caffeine: Effect on Verbal Performance," *Science* 192:149–50 (1976).
56. John F. Greden, "Anxiety or Caffeinism: A Diagnostic Dilemma," *American Journal of Psychiatrists* 131:1089–1902 (1974).
57. Federation of American Societies for Experimental Biology, *supra* note 1, at 33.
58. *Id.* pp. 21–24.
59. Matilda M. Nelson and John O. Forfar, "Associations between Drugs Administered during Pregnancy and Congenital Abnormalities of the Fetus, *British Medical Journal* 1:523–27 (1971).
60. Federation of American Societies for Experimental Biology, *supra* note 1, at 36.
61. Thomas F.X. Collins, J.J. Welch, and T.N. Black, "A Comprehen-

sive Study of the Teratogenic Potential of Caffeine in Rats When Given by Oral Intubation," *Journal of Experimental Pathology and Toxicology* (in press).

62. U.S. Food and Drug Administration, Office of Public Affairs, "Caffeine Update," talk paper T80–10, February 27, 1980, p. 3.
63. Charles G. Burch, "The Soot That Clouds the Diesel's Future," *Fortune*, December 1979, p. 60; Roger Rapoport, "The Dark Side of Diesel Chic," *Mother Jones*, Feb.–March 1980, p. 62.
64. *Ibid.*
65. U.S. Environmental Protection Agency, Office of Air, Noise, and Radiation, "Regulatory Analysis: Light-Duty Diesel Particulate Regulations," February 20, 1980.
66. Information provided by Stanley M. Blacker, Technical Advisor, Office of Mobile Source Air Pollution Control, U.S. Environmental Protection Agency.
67. Stephen Nesnow and Joellen L. Huisingh, "Mutagenic and Carcinogenic Potency of Extracts of Diesel and Related Environmental Emissions: Summary and Discussion of the Results," presented at the International Symposium on Health Effects, Cincinnati, December 3, 1979.
68. U.S. Environmental Protection Agency, "Carcinogen Assessment Group's Initial Review on Potential Carcinogenic Impact of Diesel Engine Exhaust," June 11, 1979.
69. 45 Fed. Reg. 14496 (1980).
70. 45 Fed. Reg. 5480 (1980).
71. *NRDC* v. *Costle*, No. 80–1312 (D.D.C., filed March 19, 1980).
72. *International Harvester Co.* v. *Ruckelshaus*, 478 F.2d 615, 640 (D.C. Cir., 1973).
73. Information provided by David D. Doniger, counsel, Natural Resources Defense Council.
74. 42 U.S.C. § 6901.
75. James McCarthy and Kathleen Benesch, Jackson Township, New Jersey residents, testimony before the Subcommittee on Health and Scientific Research, Senate Committee on Labor and Human Resources, June 6, 1980, pp. 10–23.
76. Information provided by John Smatusik, Superintendent of Public Works, Jackson Township.
77. *State of New Jersey, New Jersey Department of Environmental Protection* v. *Jackson Township*, C–2149–79 (Super. Ct., Chancery Div., N.D.N.J., 1980).
78. *Ibid.*
79. *Warren J. Adelund, Jr. et al.* v. *Township of Jackson*, C.A. No. 79–2613 (D.N.J., 1979).
80. *Carl L. Battaglia et al.* v. *SCM Corporation*, C.A. No. 80–2940 (D.N.J., 1980).
81. Information provided by H.J. Parr, Chief, Solid Waste Management Division, Arkansas Department of Pollution Control and Ecology.
82. Marcus M. Key et al., eds., *Occupational Diseases: A Guide to Their Recognition* (Washington, D.C.: U.S. Government Printing Office, 1977), pp. 322–23.
83. Information provided by Jack Bails, Chief, Enforcement Division, Michigan Department of Natural Resources.
84. *Shunk et al.* v. *Northwest Industries et al.*, 78–5264–NO (Cir. Ct. Gratiot County, Mich., 1978).
85. Jack Bails, *supra* note 83.
86. Subcommittee on Oversight and Investigations of the House Committee on Interstate and Foreign Commerce, *Hazardous Waste Disposal Report* (Washington, D.C.: U.S. Government Printing Office, 1979), p. 1.

87. 42 U.S.C. § 6903(5).
88. 45 Fed. Reg. 33122–27 (1980), to be codified at 40 C.F.R. §§ 261.30, 261.33.
89. 45 Fed. Reg. 33108–33112 (1980), to be codified at 40 C.F.R. § 261.
90. 45 Fed. Reg. 33072 (1980).
91. *Id.* p. 33084–85 (1980).
92. U.S. Environmental Protection Agency, Office of Water and Waste Management, *Everybody's Problem: Hazardous Waste,* SW–826 (Washington, D.C.: U.S. Government Printing Office, 1980), pp. 16–17.
93. *Id.* p. 18.
94. 45 Fed. Reg. 33071 (1980).
95. *United States* v. *Hooker Chemicals and Plastics Corporation,* C.A. No. 79–990 (W.D.N.Y., 1979).
96. 45 Fed. Reg. 12722; *id.* p. 33066 (1980).
97. *United States* v. *Hooker Chemicals and Plastics Corporation,* C.A. No. 79–987 (W.D.N.Y., 1980); *United States* v. *Hooker Chemicals and Plastics Corporation,* C.A. No. 79–988 (W.D.N.Y., 1980); *United States* v. *Hooker Chemicals and Plastics Corporation,* C.A. No. 79–989 (W.D.N.Y., 1980); *United States* v. *Hooker Chemicals and Plastics Corporation,* C.A. No. 79–990 (W.D.N.Y., 1980).
98. 42 U.S.C. § 5121.
99. 45 Fed. Reg. 37733 (1980).
100. U.S. Department of Justice, press release, December 20, 1979.
101. *United States and California* v. *Occidental Petroleum Corporation,* C.A. No. 79–989 (E.D. Ca., 1979).
102. *United States* v. *Kin-Buc, Inc.,* C.A. No. 79–514 (N.D.N.J., 1979); *United States* v. *Wade,* C.A. No. 79–1426 (E.D. Pa., 1979); *United States* v. *Laskin Greenhouse and Waste Oil Company,* C.A. No. C79–579Y (N.D. Ohio, 1979); *United States* v. *Chemicals and Minerals Reclamation, Inc.,* C.A. No. C–79–1356 (N.D. Ohio, 1979); *United States* v. *Midwest Solvent Recovery, Inc.,* C.A. No. H79–556 (N.D. Ind., 1979); *United States* v. *Solvent Recovery Services of New England and Lori Engineering Company,* C.A. No. H79–704 (D. Conn., 1979); *United States* v. *Chem-Dyne,* C.A. No. C–1–79–703 (S.D. Ohio, 1979); *United States* v. *Waste Industries, Inc.,* C.A. No. 80–4–Civ–7 (E.D.N.C., 1980); *United States* v. *Vertac Chemical Corporation, Hercules Inc.,* C.A. No. LR–C–80–109 (E.D. Ark., 1980); *United States* v. *2001 Inc., Southeastern Chemical Co. Inc.,* C.A. No. 80–0771 (E.D. La., 1980); *United States* v. *Lipari,* C.A. No. 80–791 (N.D.N.J., 1980); *United States* v. *Robert Richter, E.P.R. Inc. and Control Data Corporation,* C.A. No. 80–135–C (S.D. Iowa, 1980); *United States* v. *Union Corporation, Metal Bank of America,* C.A. No. 80–1589 (E.D. Pa., 1980); *United States* v. *W.R. Grace and Co.,* C.A. No. 80–748–C (E.D. Mass., 1980); *United States* v. *Franklin J. Dusek,* Cir. No. B80–110 (S.D. Tex., 1980); *United States* v. *Seymour Recycling Corp.,* Civ. No. IP–80–457c (S.D. Ind., 1980); *United States* v. *Ottati and Goss, Inc.,* Civ. No. C80–225–6 (D.N.H., 1980); *United States* v. *Duracell International, Inc.,* Civ. No. 80–1017 (M.D. Tenn., 1980); *United States* v. *Spectron, Inc.,* Civ. No. HM80–15–52 (D. Md., 1980); *United States* v. *American Ecological Recycle Research Corp.,* Civ. No. 80–A–811 (D. Colo., 1980); *United States* v. *Acme Refining Co.,* Civ. No. 80–C3–213 (N.D. Ill., 1980); *United States* v. *Ciszar,* Civ. No. 80–C3–385 (N.D. Ill., 1980); *United States* v. *Fisher-Calo Chemicals and Solvent Corp.,* Civ. No. S–80–204 (N.D. Ind., 1980); *United States* v. *South Carolina Recycling and Disposal,* Civ. No. 80–1274–6 (D.S.C., 1980); *United States* v. *Petro Processors of La., Inc.,* Civ. No. 80–358 (M.D. La., 1980).

103. U.S. Department of Justice, Lands and Natural Resources Division, Hazardous Waste Section, *Annual Report* (Washington, D.C., 1980), p. 1.
104. State Department Telegram '80 State 037348.
105. State Department Telegram '80 State 056968; State Department Telegram '80 Port-au-Prince 01379.
106. State Department Telegram '80 Mexico 04422.
107. 50 U.S.C. App. 2401.
108. 45 Fed. Reg. 33144 (1980), to be codified at 40 C.F.R. 262.50.
109. S. 1321, 96th Cong., 1st Sess. (1979).
110. S. 1480, 96th Cong., 1st Sess. (1979); H.R. 85, 96th Cong., 2d Sess. (1979–80); H.R. 7020, 96th Cong., 2d Sess. (1980).
111. H.R. 7020, signed on December 11, 1980.
112. *Dishner* v. *Johns-Manville*, C.A. 77–518–N (E.D. Va., 1978) (affirming award of $750,000 to the widow of a refinery worker who contracted mesothelioma); *Borel* v. *Fiberboard Paper Products*, 493 F.2d 1076 (5th Cir. 1973) (affirming an award of $58,000 to an asbestos worker who contracted mesothelioma and asbestosis); *Lester Kay et al.* v. *PPG Industries, Inc., et al.*, Civ. No. TY–74–13 (E.D. Tex., 1978); *William B. McNeece, Jr. et al.* v. *United States*, Civ. No. TY–75–22 (E.D. Tex., 1978); *Herman Yandle et al.* v. *PPG Industries et al.*, Civ. No. TY–5–75–3 (E.D. Tex., 1978) (settlement for $20 million case involving 445 former Pittsburgh Corning employees alleged to be exposed to high levels of asbestos at Tyler, Texas, plant; federal government agreed to pay $6 million). According to Leonard Andrews, publisher of the *Asbestos Litigation Reporter*, as of October 1980, 10,000 related law suits were pending.
113. Information provided by Richard Lippes, attorney for some Love Canal residents. According to Mr. Lippes, approximately 1,300 actions have been begun in the Niagara district of the New York State Supreme Court seeking $15 billion in compensatory and punitive damages from Hooker Chemicals Company, Occidental Petroleum Corporation, the City and County of Niagara Falls, the Niagara Falls Board of Education, and others.
114. *Battaglia* v. *SCM Corp.*, C.A. No. 80–2940 (D.N.J. 1980).
115. Black Lung Benefits Reform Act, 30 U.S.C. § 901
116. Council on Environmental Quality, *Environmental Quality—1979: The Tenth Annual Report of the Council on Environmental Quality* (Washington, D.C.: U.S. Government Printing Office, 1979), pp. 208–210; *Report of the Interagency Task Force on Compensation for Radiation-Related Illnesses Phase I* (Washington, D.C., U.S. Department of Justice, 1980); *Report of the Interagency Task Force on the Health Effects of Ionizing Radiation* (Washington, D.C., U.S. Department of Health, Education, and Welfare, 1979).
117. Council on Environmental Quality, *supra* note 116, at 213–14.
118. National Cancer Institute, *Asbestos: An Information Resource,* (NIH) 79–1681 (Bethesda, Md., 1978), pp. 9–20.
119. *Id.* pp. 21–39; National Institute for Occupational Safety and Health, *Revised Recommended Asbestos Standard* (Washington, D.C.: U.S. Government Printing Office, 1980), pp. 29–53; U.S. Department of Labor, *An Interim Report to Congress on Occupational Disease* (Washington, D.C.: U.S. Government Printing Office, 1980), p. 15.
120. National Cancer Institute, *supra* note 119, at 30, 31.
121. *Ibid.*
122. E. Cuyler Hammond, Irving J. Selikoff, and Herbert Seidman, "Asbestos Exposure, Cigarette Smoking and Death Rates," *Annals of the New York Academy of Sciences* 330:484–85 (1979).
123. *Restatement (Second) of Torts* §§ 282–86 (1965); Paul D. Rheingold, Norman J. Landau, Michael M. Canavan, *Toxic Torts: Tort Actions*

for Cancer and Lung Disease due to Environmental Pollution (Washington, D.C.: The Association of Trial Lawyers of America, 1977); Stephen M. Soble, "A Proposal for the Administrative Compensation of Victims of Toxic Substance Pollution: A Model Act," *Harvard Journal of Legislation* 14:703–709 (1977).

124. 42 U.S.C. § 401.
125. *U.S. Code Congressional and Administrative News,* 84th Cong., 2d Sess., 1956, p. 3877.
126. 42 U.S.C. § 423(a)(1)(B), (c)(1), (d).
127. U.S. Department of Labor, *supra* note 119, at 78.
128. *Id.* pp. 59, 80.
129. *Id.* p. 60.
130. National Commission on State Workmen's Compensation Laws, *Compendium on Workmen's Compensation* (Washington, D.C.: U.S. Government Printing Office, 1973), p. 23.
131. U.S. Department of Labor, *supra* note 119, at 76.
132. *Id.* p. 69.
133. *Id.* p. 70.
134. *Id.* p. 66.
135. 45 U.S.C. § 51 *et seq.*
136. 33 U.S.C. § 901 *et seq.*
137. 30 U.S.C. § 901.
138. 42 U.S.C. §§ 1395 *et seq.*, 1396 *et seq.*
139. 42 U.S.C. §§ 401 *et seq.*, 1381 *et seq.*
140. 42 U.S.C. §§ 301 *et seq.*, 601 *et seq.*, 801 *et seq.*, 1201 *et seq.*, 1351 *et seq.*
141. 38 U.S.C. § 301 *et seq.*
142. U.S. Department of Labor, *supra* note 119, at 58–59.
143. National Commission on State Workmen's Compensation Laws, *supra* note 130, at 287–94.
144. U.S. Department of Labor, *supra* note 119, at 76.
145. *Id.* at 67.
146. *Id.* at 66.
147. *Id.* at 67.
148. 42 U.S.C. § 401.
149. Stephen M. Soble, *supra* note 123, at 704.
150. Sheila L. Birnbaum, "Statutes of Limitations Problems in Environmental Tort Suits," in Paul D. Rheingold et al., *supra* note 123, at 412–28.
151. *Tacoma* v. *Michigan Chemical Corp. et al.,* No. 2933 (Cir. Ct., Wexford, Mich., unreported opinion, October 26, 1978).
152. See note 112, *supra.*
153. Pollution-Related Health Damage Compensation Law, Kōgai Kenkō Higai Hoshō Hō, Law No. III, Oct. 5, 1973, cited in Julian Gresser, "The 1973 Japanese Law for the Compensation of Pollution-Related Health Damage: An Introductory Assessment," 5 ELR 50229 (1975).
154. Julian Gresser, Professor of Law, University of Hawaii, testimony before the Subcommittee on Consumer Protection and Finance of the House Committee on Interstate and Foreign Commerce, hearing on H.R. 9616, 95th Cong., 2d Sess., July 25, 1978.
155. U.S. Congress, House, A Bill To Establish a Compensation System for Victims of Toxic Substance Pollution, H.R. 9616, 95th Cong., 1st Sess., 1977. For a full explanation, see Stephen M. Soble, *supra* note 123.
156. H.R. 4566, 96th Cong., 1st Sess. (1979).
157. S. 1480, 96th Cong., 1st Sess. (1979).
158. U.S. Department of Labor, *supra* note 119, at 98–107.
159. U.S. Congress, House, A Bill To Amend the Toxic Substances Control

Act To Extend the Authorization of Appropriations Contained in Such Act, and for Other Purposes, H.R. 7126, 96th Cong., 2d Sess., 1980.

160. National Institute for Occupational Safety and Health, *National Occupational Hazard Survey*, Vol. 2 (Washington, D.C.: U.S. Government Printing Office, 1977), p. 21.
161. *Id.* p. 12.
162. Information provided by David Sundin, Chief, Hazard Section, Surveillance Branch, Division of Surveillance, Hazard Evaluations and Field Studies, National Institute for Occupational Safety and Health.
163. 15 U.S.C. § 2601.
164. 7 U.S.C. § 135.
165. The 1978 FIFRA amendments divided pesticide data into two categories: pre- and post-September 30, 1978. Although certain specified confidential data submitted to EPA is public (7 U.S.C. 136h), use of the data in registration proceedings is restricted. For data supporting post-September 30, 1978, registrations of products containing new active ingredients, an applicant cannot use another's data, without obtaining permission, for 10 years from the date of the original registration of the pesticide. Applicants can rely on other data without the original submitter's consent, but for all data first submitted to EPA after 1969, the applicant relying on such data must compensate the original data submitter if the applicant seeks registration within 15 years of the date of submission (7 U.S.C. 136a(c)(1)(D)). Information provided by Edward C. Gray, Deputy Associate General Counsel, Pesticides Division, U.S. Environmental Protection Agency.
166. TSCA provides that all health and safety studies are public. However, the cost of testing new or existing chemicals will be shared, in effect, sharing data development costs for a limited time period. 15 U.S.C. 2613, 2603, 2604.
167. Toxic Substances Strategy Committee, *supra* note 2, pp. 33–61.
168. Organization for Economic Cooperation and Development, Environment Committee, "High Level Meeting of the Chemical Group: Summary Record," Paris, May 19–21, 1980, ENV/CHEM/HLM/80.M/1, pp. 77–99.
169. 45 Fed. Reg. 50544 (1980).
170. 15 U.S.C. § 2604.
171. Steven D. Jellinek, Assistant Administrator for Pesticides and Toxic Substances, U.S. Environmental Protection Agency, "New Chemicals in the 1980s: Is There Life after TSCA?" remarks before the Symposium on Regulations and the Introduction of New Chemicals, 146th National Meeting of the American Association for the Advancement of Science, San Francisco, January 5, 1980.
172. Organization for Economic Cooperation and Development, *supra* note 168.
173. 15 U.S.C. § 2604(a)(2).
174. *Id.* § 2604(e).
175. U.S. Environmental Protection Agency, "EPA Bars Manufacture of Six New Plastic Compounds," press release, April 28, 1980.
176. 15 U.S.C. § 2603.
177. 45 Fed. Reg. 48510 (1980).
178. 15 U.S.C. § 2603(e).
179. 42 Fed. Reg. 55026 (1977); 43 Fed. Reg. 16684 (1978); 43 Fed. Reg. 50631 (1978); 44 Fed. Reg. 31866 (1979); 44 Fed. Reg. 70664 (1979).
180. *NRDC* v. *Costle*, 79 Civ. 2411 (S.D.N.Y., 1979).
181. *NRDC* v. *Costle* (unreported opinion, Feb. 4, 1980).
182. 45 Fed. Reg. 48510 (1980).
183. Chemical Manufacturers Association, "Comments of the Chemical

Manufacturers Association on EPA's ANPR Concerning the Reimbursement of Test Costs under Sections 4 and 5 of TSCA," February 7, 1980, p. 7.

184. 15 U.S.C. § 2625(c).
185. 45 Fed. Reg. 48515 (1980).
186. Information provided by Warren Muir, Deputy Assistant Administrator for Toxic Substances, U.S. Environmental Protection Agency.
187. 44 Fed. Reg. 27334, 27362, 44054 (1979).
188. 15 U.S.C. § 2607(a).
189. 45 Fed. Reg. 13646 (1980).
190. Chemical Manufacturers Association, "Comments of the Chemical Manufacturers Association, Inc., on EPA Proposed Regulations for Submission of Lists and Copies of Health and Safety Studies under Section 8(d) of TSCA," February 29, 1980, pp. 1–11.
191. 44 Fed. Reg. 77470 (1979).
192. 43 Fed. Reg. 25711 (1978).
193. United Nations Environment Programme, Governing Council Decision, 5th Session, May 1977, reprinted in *Hearing on the Export of Hazardous Substances,* Subcommittee on Commerce, Consumer and Monetary Affairs of the House Committee on Government Operations, 95th Cong., 2d Sess., 1978, p. 76.
194. *Hearing on the Export of Hazardous Substances, supra* note 193.
195. 15 U.S.C. §§ 2053, 2056, 2058, 2067–2069, 2076, 2081; 7 U.S.C. §§ 135–136y.
196. U.S. Congress, House, *A Bill To Amend the Export Administration Act of 1979 To Restrict the Export of Goods Which Have Been Found To Be Hazardous to the Public Health,* H.R. 6587, 96th Cong., 2d Sess., 1980.
197. Robert H. Harris, Co-Chair of the Interagency Working Group on a Hazardous Substances Export Policy, testimony before the Subcommittee on International Economic Policy and Trade of the House Committee on Foreign Affairs, June 12, 1980.
198. 50 U.S.C. App. § 2401.

Chapter 6

ENERGY

The past year has been one of significant progress on long-term energy problems. Perhaps the most notable gains were in energy efficiency, largely the result of Administration policies to decontrol oil and gas prices. In developing new energy sources, the Administration and the Congress have made major commitments to accelerating the use of synthetic fuels in an environmentally acceptable way. Enactment of the Energy Security Act[1] and the Crude Oil Windfall Profit Tax Act of 1980[2] gave the President additional tools to encourage development of remaining oil and gas reserves and of a synthetic fuels industry.

Coal, the nation's largest fossil fuel resource, may well play a larger role in the next several decades in reducing reliance on oil and natural gas. The Administration has encouraged electric utilities to substitute coal for oil in power generation and has explored the feasibility of increasing coal exports to alleviate global dependence on petroleum. Although coal is the largest domestic fossil resource, like other fossil fuels, it cannot be used in ever larger amounts without posing long-term climatic risks from buildup of carbon dioxide. The problem is reviewed in this chapter, along with the impacts of eventual widespread use of biofuels and hydrogen as energy sources.

The Administration has taken steps to solve two nuclear energy problems—safety and waste disposal. In accepting the substantive recommendations of the Kemeny Commission following its review of the Three Mile Island accident, the President established a systematic process to deal with the many institutional problems of regulating the nuclear power industry. He also initiated a program to develop a technically and publicly acceptable plan for disposing of radioactive wastes.

The most encouraging signs on the national energy situation are the economy's response in improving overall energy productivity. Ordinarily, changes in energy habits and patterns occur slowly, with significant change measured in years and sometimes decades. Yet a review of the past year's private and government reports, data on consumption, and incidents reported in newspapers clearly shows

FEDERAL CONSERVATION AND SOLAR PROGRAMS

Research, Development, and Financial Incentives and Assistance

- Weatherization assistance for low-income persons who do not benefit from existing tax credits and are unable to make investments in conservation equipment without assistance, $0.2 billion annually.
- Conservation loan subsidies through the Solar Energy and Conservation Bank will provide $2.5 billion between 1980 and 1984 to lenders for long-term, below-market rate loans.
- Solar loan subsidies through the Solar Energy and Conservation Bank will provide $0.5 billion over the next three years to finance use of solar energy systems. Passive solar buildings will be eligible for these subsidies.
- Residential solar, wind, and geothermal tax credits for investments by residential users (40 percent of the first $10,000) of $1.3 billion through 1985.
- Residential conservation tax credits of $2.5 billion through 1985, representing about $17 billion in consumer investments.
- Conservation RD&D, roughly $0.3 billion annually.
- Business conservation, geothermal, and solar tax credits of $4 billion through 1990 for investments in, for example, solar, wind, and geothermal equipment; solar process heat equipment; small hydroelectric dams; and cogeneration equipment.
- Biomass—combined alcohol tax exemption credit of $1.6 billion through 1990 to promote conversion of grain, farm residues, and other biomass into alcohol fuels; a commitment of $1.45 billion in direct government spending to support commercial biomass projects.
- Industrial development bond tax subsidies for solar and conservation —$0.5 billion through 1990.
- Conservation grants ($0.2 billion in fiscal year 1981) to schools and hospitals which could not make energy-saving investments without assistance.
- Solar RD&D—about $0.9 billion annually.
- Transportation efficiency—$16.5 billion through 1990, including public transportation assistance in bus purchases and system improvements; a fuel economy standards improvement program; a cooperative basic automotive research program; auto use management programs to upgrade vehicle inspection stations, to improve enforcement of the 55 mile-per-hour speed limit, and to increase support for ride-sharing and pedestrian and bicycle projects.
- Conservation improvements in federal buildings (more than $1.25 billion through fiscal year 1981) will increase energy efficiency in existing buildings.

that the United States is already heading in a new direction, brought about by the reality of higher energy prices. These changes could not have been forecast just a few years ago.

Most important among the newly discovered energy facts of life are the economic and social benefits of conservation and efficiency. From its inception, the Carter Administration has strongly advocated energy conservation as the most readily available—and

Regulatory Programs and Other Incentives To Encourage Energy Efficiency

- Auto efficiency standards—The major government transportation conservation policy for autos is the mandatory auto fuel efficiency standards. The average mileage for new cars must rise from a 1980 model year average of 20 miles per gallon to 27.5 mpg by 1985.
- Gas guzzler tax—An Administration-proposed gas guzzler tax became effective with the 1980 model year autos. The 1980 tax is $200 or more on sales of new vehicles with mileage below 15 mpg. In 1985 the tax will be $500 or more for cars below 21 mpg, $1,000 on 17 mpg cars, and $2,650 on 12 mpg cars.
- Building energy conservation code—Under a 1976 law, the federal government is developing energy performance standards for new residential and commercial buildings. The standards will provide flexibility for designers and builders and, over time, should help effect energy savings by reducing heat losses and by encouraging the use of passive solar energy and other advanced design techniques.
- Appliance efficiency standards—Under the National Energy Act, energy efficiency standards are being developed for refrigerators, air conditioners, and other major home appliances.
- Utility rate reform—Under the National Energy Act, state public utility commissions are required to consider time-of-day rates, interruptible rates, load management techniques, and other forms of rate reforms and policies to encourage economically efficient use of resources. The Act also requires states to adopt specific reforms (such as a prohibition on master metering), when appropriate. There are also provisions, now being implemented, to facilitate the wide use of equipment to cogenerate electricity and heat efficiently.
- Removal of the prohibition on utility financing of conservation—The President strongly supported repeal of prohibitions in the National Energy Act which discouraged utilities' financing energy conservation investments. These provisions were repealed by the Energy Security Act passed in June 1980.
- Temperature restrictions in commercial buildings—On April 15, 1980, President Carter extended the Emergency Building Temperature Restriction Program to January 1981. The Program is estimated to be saving between 200,000 and 400,000 barrels of oil (equivalent) per day.
- Residential conservation services program—Utilities are required to offer "energy audits" to homeowners and to offer to obtain financing of conservation measures. To carry out these "audits," the program also provides $35 million for training personnel, including $25 million to test the feasibility of "house doctor audits."

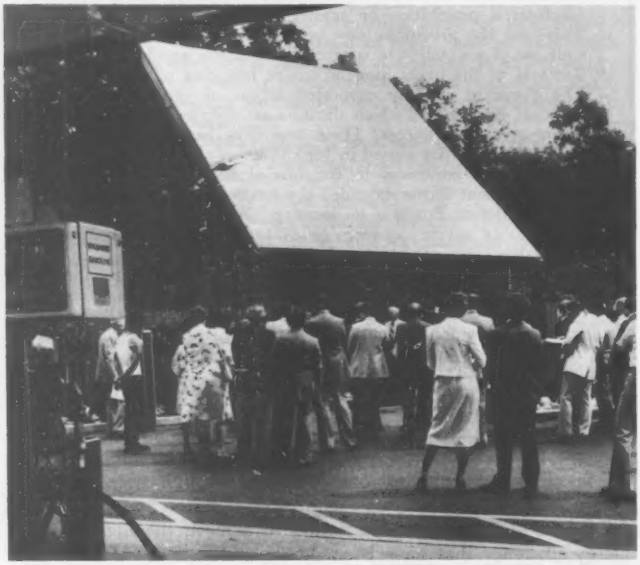
most environmentally benign—means of reducing oil imports. Today the feasibility of reducing energy needs through conservation is widely accepted, and attention both in Washington and in the states has turned to finding the best ways to achieve the high levels of energy efficiency that have been shown in one study after another to be technically and economically possible.

The federal approach to these problems in the last few years has been to encourage efficiency in energy use through incentives and

rewards. The principal incentive is more realistic energy pricing. With the phased decontrol of petroleum and natural gas adopted by the President and the Congress in 1979, prices more accurately reflect replacement costs in world markets. Higher fuel prices appear to be affecting energy growth rates. Between 1978 and 1979, gasoline use declined 5 percent, and it dropped further in the first half of 1980. Although the 1980 decline was partly a function of the overall slowdown in economic activity, it may well have reflected consumer response to higher prices. In addition, the purchase of more efficient cars has undoubtedly contributed to reductions in gasoline use.

Complementing phased decontrol of fuel prices was a program of residential and business tax credits, subsidized loans, grants, RD&D (research, development, and demonstration), and regulation to encourage energy efficiency and use of renewable energy technologies.

The most significant improvements in energy efficiency so far have occurred in the industrial and transportation sectors. New equipment (more efficient vehicles and manufacturing processes) and improved operating procedures have increased energy productivity noticeably.



Amoco opened this Solar gas station in Chicago during 1980. It supplies 5 kilowatts of power at peak and charges batteries to operate the pumps (Solarex).

These improvements have not been matched in the operation of commercial and multifamily apartment buildings, where a host of institutional factors—from rent control to master metering—work against efficient design and operation. Also inhibiting energy conservation is the lack of an effective delivery system. Unlike the situation with cars and industrial equipment, there are few conservation experts ("house doctors," as they have come to be known) who are both qualified and credible to diagnose energy illnesses and to prescribe cures for leaky and inefficient buildings.

A proposal to increase energy efficiency that is currently receiving widespread attention at both state and federal levels is the active involvement of utilities in financing and installing both conservation and solar equipment. The thrust of the proposals is to broaden the services of utilities from supplying energy (electricity or natural gas) to supplying energy-related services.

Utilities have ready access to capital markets, and they could raise the funds needed to improve building efficiency provided that they were able to make an adequate rate of return on investments. Utilities already have or can easily acquire the technical expertise to provide accurate energy audits ("house doctor calls") and to monitor installation of conservation and solar investments. Hence they are in a good position to offer a solution to the delivery system problem.

In fact, several utilities are providing the kinds of services outlined above. The Pacific Power and Light Company, based in Portland, Oregon, has offered audits and interest-free conservation loans to its heating customers for about 2 years. Until a home is sold, the loan is placed in the utility's rate base. This arrangement allows the utility to make its rate of return on the investment, just as it would with a new power plant. When a home is sold, the interest-free loan is paid back and removed from the rate base.[3]

The California Public Utility Commission has ordered all utilities to propose programs for financing both weatherization and installation of solar hot water systems.[4] In California, Hawaii, Massachusetts, and Washington, utilities are experimenting with wind machines.[5] "Wind farms," composed of many wind turbines, are being tested for their economics and feasibility.

Utilities offer a promising means of rapidly introducing and integrating renewable energy technologies, including thermal collectors, wind machines. photovoltaic cells, small hydro dams, and wood-burning power plants. Whether the utilities will ultimately have a major role in achieving national conservation and solar goals is by no means certain, and there are many who object to the utilities' being involved, primarily because their involvement could stifle competition and lead to higher consumer costs. What is clear, however, is that the utilities could bring both the capital and the technical expertise to solving two important and intractable energy problems—the retrofitting of existing buildings to improve their

energy efficiency and the integration of renewable energy technologies into the present energy delivery system.

The overall benefits of energy conservation were once again attested in a Mellon Institute report, *The Least-Cost Energy Strategy*, published in September 1979.[6] It concluded that had the nation made the conservation investments that were economically justified in the last 10–15 years, consumer outlays for energy services would have been reduced 17 percent in 1978. Further, both national security and environmental quality would have benefited.

Extrapolating the calculations for the hypothetical 1978 case, the report concluded that if the present emphasis on energy efficiency continues through the 1980s, the nation could be using about the same amount of energy in 1990 as it does today while satisfying a much larger demand for energy services. A 2.5 percent real growth in GNP was postulated for the coming decade.

Nearly as noteworthy as these findings was the reaction of energy experts. Although the Mellon report may well have been subject to major scrutiny just a decade ago, it now appears to be accepted almost without question.

NATIONAL ENERGY DEMAND AND SUPPLY

ENERGY DEMAND

Total domestic energy consumption in 1979 rose only modestly from its 1978 level. This fact appears to be largely the result of the energy system's overall response to rapidly changing economic factors. Since the 1973 oil embargo and subsequent energy price increases, the overall efficiency in energy use has continually increased. A general measure of this trend, the energy required per unit of national output, has declined each year since the embargo. Preliminary data for 1979 suggest that the ratio dropped to about 55,000 Btu per (1972) dollar of gross national product. This figure is nearly 9 percent lower than the 1973 ratio of 60,400 Btu per dollar of GNP (1972 dollars). Table 6–1 summarizes the ratio since 1973.

Real supply shortages, notably those associated with gasoline during the spring and summer of 1979, do not appear to have influenced gross energy consumption markedly. Shortages were confined primarily to specific regions and were of relatively short duration.

The overall trend toward a much slower growth or stabilization in gross energy consumption is reflected in a substantial decrease over time in the level of energy demand forecasted for the year 2000. Table 6–2 summarizes representative forecasts made between 1960 and 1980. Before the 1973 embargo, year 2000 consumption was typically estimated to be in the range of 180 QBtu (quadrillion British thermal units). Recent estimates have generally been around 100 quads.

Table 6–1

Energy Consumption per GNP Dollar, 1973–79

Indicator	1973	1974	1975	1976	1977	1978	1979
Energy consumption (thousand Btu per 1972 dollar)	60.4	59.7	58.8	58.5	56.0	55.9	55.0
Annual consumption (QBtu)	74.6	72.8	70.7	74.5	76.4	78.2	78.8
Annual GNP (trillion dollars)							
Current	1.31	1.41	1.53	1.70	1.90	2.13	2.37
1972 [a]	1.24	1.22	1.20	1.27	1.34	1.40	1.43

1 QBtu = 1 quadrillion British thermal unit = 1 quad.

[a] Current dollars converted to 1972 constant dollars by the formula:

$$\text{constant 1972 dollars} = \frac{\text{current dollars in year N}}{\text{GNP implicit price deflator in year N}} \times 100$$

The GNP deflators (1972 = 100) and the GNP rates are from the U.S. Department of Commerce, Bureau of Economic Analysis.

Source: U.S. Department of Energy, *Monthly Energy Review*, DOE/EIA 0035/80 (06) (Washington, D.C.: U.S. Government Printing Office, June 1980), p. 12.

Table 6–2

Representative Forecasts of U.S. Total Energy Consumption for the Year 2000

Source	QBtu
Atomic Energy Commission, 1960	170
Resources for the Future, 1963	135
Bureau of Mines, 1968	159–169
Resources for the Future, 1971	190
Bureau of Mines, 1971	166–239
Department of the Interior, 1972	192
Federal Power Commission, 1973	203
National Petroleum Council, 1973	200
Ford Foundation, 1974	100–124 [a]
Atomic Energy Commission, 1974	195
Council on Environmental Quality, 1974	121
Energy Research and Development Administration, 1975	121–164
Institute of Electrical and Electronic Engineers, 1975	171
Edison Electric Institute, 1976	105–180 [b]
Institute for Energy Analysis, 1976	101–126
Hudson and Jorgenson, 1978	90–116 [c]
Council on Environmental Quality, 1979	80–90 [d]
Department of Energy, 1979	117–123
Energy Information Administration, 1979	122
National Academy of Sciences, 1979	65–130 [a]
Exxon Corporation, 1979	102
Resources for the Future, 1979	97–140
Edison Electric Institute, 1980	77–147
Energy Information Administration, 1980	104–113

[a] Range based on the recommended technical-fix/zero-energy-growth scenarios.

[b] Approximate range based on the Executive Summary.

[c] Range based on middle-range policy scenarios.
[d] Range assumes a determined national effort to increase energy productivity.
[e] Approximate range based on year 2010 estimates.

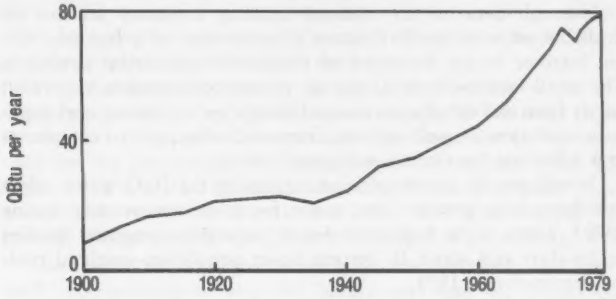
Sources: AEC, 1960: Milton F. Searl, U.S. Atomic Energy Commission, Office of Operations Analysis and Forecasting, *Fossil Fuels in the Future* (Washington, D.C.: U.S. Government Printing Office, 1960). RFF, 1963: H.H. Landsberg, L.L. Fischman, and J.L. Fisher, Resources for the Future, Inc., *Resources in America's Future* (Baltimore: Johns Hopkins Press, 1963). BOM, 1968: U.S. Bureau of Mines, *An Energy Model for the United States Featuring Energy Balances for the Years 1947 to 1968 and Projections and Forecasts to the Years 1980 and 2000*, IC 8384 (Washington, D.C.: U.S. Government Printing Office, 1968). BOM, 1971: U.S. Bureau of Mines, *Mineral Facts and Problems—1970 Edition* (Washington, D.C.: U.S. Government Printing Office, 1971). RFF, 1971: Joel Darmstadter, *Trends and Patterns in U.S. and Worldwide Energy Consumption—A Background Review* (Washington, D.C.: Resources for the Future, Inc., Forum on Energy, Economic Growth and the Environment, April 20–21, 1971). DOI, 1972: Walter G. Dupree, Jr., and James A. West, *United States Energy through the Year 2000* (Washington, D.C.: U.S. Government Printing Office, 1972). FPC, 1973: John N. Nassikas, Chairman, Federal Power Commission, and Warren E. Morrison, Federal Power Commission, testimony before the Senate Committee on Interior and Insular Affairs, 93d Cong., 1st Sess., Jan. 11, 1973. NPC, 1973: National Petroleum Council, *U.S. Energy Demand, Energy Demand Task Group* (Washington, D.C., 1973). AEC, 1974: U.S. Atomic Energy Commission, Office of Planning and Analysis, *Nuclear Power Growth 1974–2000* (Washington, D.C.: U.S. Government Printing Office, 1974). CEQ, 1974: Russell W. Peterson, Chairman, Council on Environmental Quality, "A National Energy Conservation Program: The Half and Half Plan," March 1974. Ford, 1974: Ford Foundation, Energy Policy Project, *A Time To Choose: America's Energy Future* (Cambridge, Mass.: Ballinger Publishing Co., 1974). ERDA, 1975: U.S. Energy Research and Development Administration, *A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future*, Vol. I (Washington, D.C.: U.S. Government Printing Office, 1975). IEEE, 1975: C.A. Falcone, Working Group Chairman, "Electric Energy Technology Forecast: Energy Needs," presented at the International Convention of the Institute of Electrical and Electronic Engineers, New York, April 8–11, 1975. EEI, 1976: Edison Electric Institute, *Economic Growth in the Future* (New York: McGraw-Hill, Inc., 1976). IEA, 1976: Oak Ridge Associated Universities, Institute for Energy Analysis, *U.S. Energy and Economic Growth, 1975–2010*, ORAU/IEA 76–7 (Oak Ridge, 1976). Hudson-Jorgenson: E.A. Hudson and D.W. Jorgenson, "Energy Policy and U.S. Economic Growth," *The American Economic Review* 68:120 (1978). CEQ: Council on Environmental Quality, *The Good News about Energy* (Washington, D.C.: U.S. Government Printing Office, 1979), p. 18. DOE, 1979: U.S. Department of Energy, *National Energy Plan II* (Washington, D.C.: U.S. Government Printing Office, 1979). EIA, 1979: U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1978*, Vol. Three: *Forecasts*, DOE/EIA–0173/3 (Washington, D.C.: U.S. Government Printing Office, 1979). NAS, 1979: National Academy of Sciences, National Research Council, Committee on Nuclear and Alternative Energy Systems, *Energy in Transition 1985–2010* (San Francisco: W.H. Freeman and Co., 1979). EXXON, 1979: Exxon Corporation, *Energy Outlook 1980–2000* (New York, 1979). RFF: S.H. Schurr et al., *Energy in America's Future* (Baltimore: Johns Hopkins University Press, 1979), p. 193. EEI, 1980: Edison Electric Institute, *Economic Growth in the Future*, Vol. II: *Executive Summary* (Washington, D.C., 1980). EIA, 1980: U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979*, Vol. Three: *Forecasts*, DOE/EIA–0173(79)/3 (Washington, D.C.: U.S. Government Printing Office, 1980).

Total U.S. energy consumption in 1979 is estimated at 78.8 QBtu, an increase of approximately 0.8 percent over the 1978 level of 78.2 (see Figure 6–1). This small percentage increase is markedly lower than the 3-year (1976–78) annual growth rates of 2–5 percent.

Consumption of petroleum and natural gas—two major energy sources—changed little between 1978 and 1979; petroleum consumption decreased 2.2 percent and natural gas consumption in-

Figure 6-1

U.S. Gross Energy Consumption, 1900-1979



Source: U.S. Department of Energy, *Monthly Energy Review*, DOE/EIA 0035/80 (06) (Washington, D.C.: U.S. Government Printing Office, June 1980).

creased 2.7 percent. Coal consumption increased 8.6 percent, and nuclear electric power consumption decreased 7.7 percent. The annual consumption growth rate for each major source and its share of total energy consumption for 1979 are shown in Table 6–3.

Energy use trends are clearly different for the residential-commercial, industrial, and transportation sectors. Of the three, the residential-commercial (R/C) sector recorded the largest increase in total energy used in 1979—about 3 percent, reaching 29.8 QBtu. Natural gas use in this sector increased roughly 6 percent; petroleum remained almost constant, declining 0.1 percent; and electric energy grew at a relatively low rate, roughly 2 percent. Wood, which repre-

Table 6–3

Growth Rates and Share of Total Energy Consumption by Source, 1979

(percentage)

Source	Growth rate	Share of total
Petroleum	−2.2	47
Natural gas	+2.7	26
Coal	+8.6	19
Nuclear power	−7.7	3
Hydropower	−0.2	4

Totals may not equal 100 because of rounding and because small contributions from coal coke, geothermal, wood, and wastes are omitted.

Source: U.S. Department of Energy, *Monthly Energy Review*, DOE/EIA 0035/80 (06) (Washington, D.C.: U.S. Government Printing Office, June 1980).

sents a small but growing source for home heating in many rural areas, was not included in the Department of Energy (DOE), Energy Information Administration, statistics used here.[7]

Although data on the national building inventory are not yet available, some of the R/C sector increase may be a function of a net increase in the inventory of residential-commercial structures. The small increase in R/C electric energy consumption may result partly from individual awareness of energy use in lighting and appliance operation as well as from increased reliance on heat pumps as a substitute for electric resistance heating.

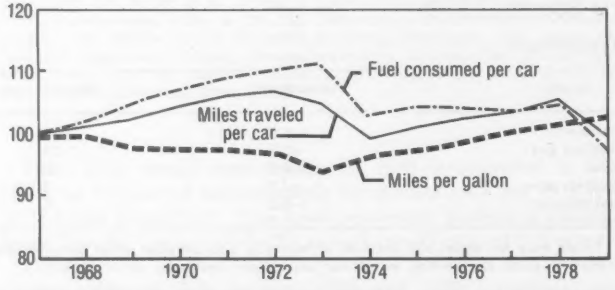
Overall growth in energy consumption in the R/C sector might well have been greater were it not for moderate weather during 1979.[8] There were 4 percent fewer population-weighted heating degree-days and about 10 percent fewer population-weighted cooling degree-days in 1979.

In the industrial sector, energy use increased about 2 percent, totaling 29.2 QBtu in 1979 compared with 28.6 in 1978, and production increased about 4 percent. Natural gas use declined approximately 2.4 percent. Coal, petroleum, and electricity consumption each increased roughly 3–4 percent. Over the last several years, the industrial sector has made major energy efficiency improvements. Even though industrial production rose 17 percent between 1973 and 1979, energy consumption increased only about 2 percent.

The amount of energy used in the transportation sector declined to about 19.8 QBtu in 1979, compared with 20.6 QBtu in the previous year, a 4 percent decrease. A decline in gasoline consumption of roughly 5 percent is believed to have been caused by continued improvements in average fuel economy and the general reduction in travel occasioned by sharply higher fuel prices. As Figure 6–2 indicates, the average passenger car fuel efficiency has

Figure 6-2

U.S. Passenger Car Efficiency Index, 1967-79



Sources: U.S. Department of Energy, *Monthly Energy Review*, DOE/EIA 0035/05 (80) (Washington, D.C.: U.S. Government Printing Office, 1980); 1979 data from Federal Highway Administration.

continued to increase since 1973, when the record low was about 13.1 miles per gallon. Preliminary data suggest a 1979 average of 14.3 mpg. This figure is slightly higher than the 1967 average of 13.9. Until recently fuel economy improvements were more than offset by a steady increase in the average miles traveled per vehicle and the growth in the number of vehicles.

With the notable exception of transportation, the major end use sectors consume large quantities of electricity. National trends in electric utilities are thus especially significant. In 1979, energy used for the generation of electricity rose 4.2 percent, from 23.4 QBtu in 1978 to 24.4 QBtu. Confounding higher projections made the previous year, this growth was little more than one-half the average annual growth rate for electric utilities in pre-embargo days.

There were also changes in the ways that electricity was generated. The amounts of coal and natural gas used by utilities rose sharply (each grew roughly 10 percent). At the same time, petroleum consumption by electric utilities dropped about 7 percent. Nuclear power generation declined 8 percent, at least in part because of the accident at Three Mile Island.

ENERGY SUPPLY

As Table 6–4 shows, domestic energy production reached 63.5 QBtu in 1979—an increase of about 4 percent over 1978; 1979 was the first year in which domestic production exceeded its 1973 level. The increase was caused largely by higher coal production, which increased about 16 percent over its 1978 level (depressed that year by a national coal strike). Although domestic production of crude oil declined 2 percent, natural gas production increased 2 percent. At the same time, hydroelectric power (almost exclusively from large dams) remained essentially constant. As already noted, nuclear electric power generation fell about 8 percent.

The DOE best estimate of the amount of usable energy from all active solar thermal collectors was 0.008 QBtu in 1979. On a fuel-equivalent replacement basis, this value would be somewhat larger (because, for example, only 30–40 percent of the Btu value of fuels is captured in the generation of electricity). Fuel-equivalent replacement energy from small-scale hydroelectric facilities (less than 30 megawatts electric) was 0.15 QBtu in 1978, the most recent year for which data are available.[9] Most, perhaps 90 percent, of the small-scale hydro is included in the DOE overall production statistics shown in the table.

Although not yet fully incorporated into national statistics, the contribution of biomass—wood, municipal and agricultural wastes, crops, and sewage—appears significant, on the order of 1.5–1.9 QBtu.[10] National energy statistics do not yet include wind energy conversion systems and photovoltaic cells. These sources are known

Table 6–4

Energy Production by Source, 1973–79

(QBtu)

Source	1973	1974	1975	1976	1977	1978	1979
Coal [a]	14.4	14.5	15.2	15.9	15.8	15.0	17.4
Crude oil [b]	19.5	18.6	17.7	17.3	17.5	18.4	18.1
Natural gas plant liquids	2.6	2.5	2.4	2.3	2.3	2.2	2.4
Natural gas (dry)	22.2	21.2	19.6	19.5	19.6	19.5	19.9
Hydroelectric power [c]	2.9	3.2	3.2	3.0	2.3	3.0	3.0
Nuclear electric power	0.91	1.27	1.90	2.11	2.70	2.98	2.75
Other [d]	0.05	0.06	0.07	0.08	0.08	0.07	0.09
Total energy	62.4	61.2	60.1	60.1	60.3	61.2	63.5

Totals may not equal sum of components because of rounding.
[a] Includes bituminous coal, lignite, and anthracite.
[b] Includes lease condensate.
[c] Includes industrial and utility production.
[d] Includes geothermal power and electricity produced from wood and waste.

Source: U.S. Department of Energy, *Monthly Energy Review*, DOE/EIA 0035/80 (06) (Washington, D.C.: U.S. Government Printing Office, June 1980), p. 4.

to contribute only a small fraction of 1 percent of the nation's energy supply.

Net domestic imports of energy decreased for a second consecutive year, falling about 3.5 percent to 16.7 QBtu. Nevertheless, imports were still some 30 percent higher than in 1973; the figures are shown in Table 6–5. Crude oil imports rose approximately 0.7 percent during the year, and refined petroleum imports fell 6 percent. Imports of natural gas rose 30 percent (roughly 0.3 QBtu), reaching a level of approximately 1.2 QBtu in 1979. Coal *exports* recovered from their 1978 decline, roughly equaling previous levels. Large price increases for imported crude and petroleum products increased the current dollar value of energy imports from about $42 billion in 1978 to about $60 billion in 1979.

MAJOR LEGISLATIVE INITIATIVES

The continuing heavy dependence of the United States on unreliable foreign sources of oil remains one of the most serious economic and national security problems. In addition to deregulating the price of oil and gas, the President proposed three major legislative initiatives during 1979 to reduce foreign oil imports in the 1980s—creation of an Energy Mobilization Board, creation of an Energy Security Corporation (as revised by the Congress, the Synthetic Fuels Corporation), and establishment of a windfall profits tax.

Table 6–5

Net Energy Imports by Source, 1973–79

(QBtu)

Source	1973	1974	1975	1976	1977	1978	1979
Coal [a]	(1.4)	(1.6)	(1.8)	(1.6)	(1.4)	(1.0)	(1.7)
Crude oil [b]	6.9	7.4	8.7	11.2	13.9	13.1	13.2
Refined petroleum products [c]	6.1	5.3	3.8	4.0	4.3	3.9	3.7
Natural gas (dry)	0.98	0.91	0.90	0.92	0.98	0.94	1.2
Electricity	0.15	0.13	0.06	0.09	0.18	0.21	0.21
Coal coke	(0.01)	0.06	0.01	0.00	0.02	0.13	0.07
Net imports	12.7	12.2	11.7	14.6	18.0	17.3	16.7

Data are for the 50 states and the District of Columbia.

Totals may not equal sum of components because of rounding.

Parentheses indicate that exports are greater than imports; net imports are imports minus exports.

[a] Includes bituminous coal, lignite, and anthracite.

[b] Includes crude oil, lease condensate, and imports of crude oil for the Strategic Petroleum Reserve.

[c] Includes refined petroleum products, unfinished oils, natural gasoline, and plant condensate.

Source: U.S. Department of Energy, *Monthly Energy Review*, DOE/EIA 0035/80 (06) (Washington, D.C.: U.S. Government Printing Office, June 1980), p. 8.

THE ENERGY MOBILIZATION BOARD

In July 1979, the President proposed that the Congress create an Energy Mobilization Board (EMB), which would accelerate completion of key nonnuclear energy projects by cutting through red tape and procedural delays. Substantive federal, state, and local laws would remain intact unless passed after a project began (a "grandfather" clause). For designated priority energy projects, the EMB would establish binding decision schedules for any necessary approvals at the federal, state, or local level. If an agency failed to comply with a project's decision schedule, the Board would be empowered to make the decision itself.

The Conference labored over 6 months to resolve the differences between bills passed by the House and the Senate. The most controversial issue was the House provision for a waiver of substantive federal law. Conferees finally agreed upon a case-by-case waiver of substantive federal law, subject to Congressional approval. In June the House unexpectedly voted down the EMB bill by a large margin and sent it back to conference.

THE ENERGY SECURITY CORPORATION

The President also proposed creating an Energy Security Corporation (ESC), envisioned as an independent, government-sponsored

corporation with authority to provide incentives to private firms to develop synthetic fuels and unconventional natural gas. After nearly 1-year's deliberation, the Congress passed the legislation, and on June 30, 1980, the President signed the Energy Security Act.[11] It establishes a Synthetic Fuels Corporation (SFC) to stimulate the production of 2 million barrels per day of synthetic fuels by 1992, a Solar Energy and Conservation Bank, biomass financial assistance programs, a minimum rate for filling the Strategic Petroleum Reserve, and statutory support for electric and gas utility investments in energy conservation.

The SFC was established as an independent federal entity, with immediate authorization of $20 billion, which may be increased to a total of $88 billion for synthetic fuels development if the Congress approves a second phase of corporation activities. The interim goal of the SFC will be to produce 500,000 barrels per day of synthetic fuels by 1987. The SFC will share the risk of commercial-scale synthetic fuels projects with the private sector through loan guarantees, price guarantees, direct loans, purchase agreements, joint ventures, and possible direct SFC ownership.

The Act also establishes the Solar Energy and Conservation Bank within the Department of Housing and Urban Development. It authorizes over $1.5 billion in subsidies within the first 4 years for residential and commercial investment in energy conservation and renewable energy development.

THE WINDFALL PROFIT TAX

The President proposed the windfall profit tax in April 1979 to capture a portion of the increase in oil producer income caused by decontrol of oil prices and oil price increases. The tax was enacted in March 1980.[12] It is designed to collect a total of $227 billion; when this amount has been collected, the tax will be phased out over 33 months.

Although the tax does not cause the price of oil to increase, it reduces the profits from oil production. Because of interaction with the income tax (the new tax is deductible), the effect on producers, although complex, is not likely to exceed 25 percent of the price of crude oil, even with oil prices of more than $50 per barrel. The effect on new oil is substantially smaller, thus preserving the incentive for new oil production. The tax law also increased the residential credit for renewable resources from 15 to 40 percent.

ASSESSMENT OF DOE ENVIRONMENTAL AND CONSERVATION POLICIES

The Environmental Protection Agency (EPA) is directed by the federal Nonnuclear Energy Research and Development Act, as amended, to conduct a "continuing analysis of the adequacy of attention to energy conservation methods and environmental pro-

tection . . . and the environmental consequences of the application of energy technologies." [13] Responsibility for this analysis, originally placed with the Council on Environmental Quality, was transferred to EPA in mid-1977.

EPA's 1979 review of DOE planning and management processes emphasized the environment. In its report, EPA described DOE's major project review and environmental assessment systems, using geothermal energy RD&D as a case study.[14]

The EPA review raised questions about the DOE management system and its ability to influence technology development. If it can influence development, does it lead to diversion of resources to environmentally benign technologies or to improving the environmental performance of emerging technologies? EPA found that although DOE management was able to identify environmental concerns, it was not able to effect tangible and significant changes in the Agency's research direction.[15] Overall attention to environmental concerns was found less than desirable. EPA concluded that DOE should modify its management system and improve procedures to ensure that environmental concerns are handled adequately and expeditiously.

SELECTED ISSUES IN ENERGY SUPPLY

THE CARBON DIOXIDE PROBLEM

In the past year the CO_2 problem and its possible adverse climate effects have drawn increased attention from scientists and policymakers [16] because the concentration of carbon dioxide in the earth's atmosphere is steadily rising. It is known to have increased about 7 percent since 1958, and the increase is estimated at 15–25 percent since the beginning of the Industrial Age (about 1800).[17] A major contributor of CO_2 to the atmosphere is the combustion of fossil fuels.[18] Most estimates of global energy use suggest that CO_2 concentrations could reach twice the pre-industrial level around the middle of the 21st century.[19]

Atmospheric CO_2 causes a "greenhouse" effect by allowing incoming short wave solar radiation to pass through to the earth while partially trapping outgoing infrared heat radiated by the earth. The higher the atmospheric concentration of CO_2, the more heat is trapped. Thus it is believed that, unless the greenhouse effect is offset by other climate-related factors, increased atmospheric concentrations of CO_2 will eventually raise average temperatures of the earth's surface. It is estimated that a doubling of the atmospheric CO_2 concentration could raise average global surface temperatures about 3° C (5.4° F) and increase the winter average in the north polar region as much as 7°–10° C.[20]

There are significant uncertainties in the prediction of climatic and socioeconomic effects of such a global warming.[21] Possible cli-

matic effects include changes in wind direction and speed, in ocean currents, and in precipitation patterns. If these large-scale climatic changes occurred, the socioeconomic impacts would be significant. If the warming continued long enough, polar ice could melt and sea levels would rise, forcing a gradual evacuation of heavily populated coastal areas. Agricultural patterns would change as well. In some regions existing agricultural infrastructure could become obsolete. But in other regions, increased atmospheric CO_2 may benefit agriculture, at least in the short term, and reduce heating requirements in buildings.[22]

Most of the world's readily exchangeable carbon is contained in four global reservoirs—the ocean's upper layer, the atmosphere, fossil fuels, and the land biosphere. Flow patterns and exchange rates of carbon among these reservoirs are complex. The documented increases in atmospheric CO_2 concentrations account for about one-half the CO_2 emitted globally by the burning of fossil fuels. The remaining CO_2 is presumably taken up largely by the oceans and, perhaps, somewhat by the biomass.[23] Although global deforestation may also contribute net CO_2 to the atmosphere, recent work suggests that the land biosphere is neither a significant CO_2 source nor a sink.

At least three government efforts focused on the CO_2 problem were undertaken or continued during 1979–80, two short reports by the National Academy of Sciences (NAS) and the continuing DOE carbon dioxide research program.

The first of the NAS studies, *Carbon Dioxide and Climate: A Scientific Assessment,* reviewed the climatic models used to predict temperature and climatic effects of increased atmospheric CO_2. It concluded:

> If carbon dioxide continues to increase, the study group finds no reason to doubt that climate changes will result and no reason to believe that these changes will be negligible. The conclusions of prior studies have been generally reaffirmed. . . . A wait and see policy may mean waiting until it is too late.[24]

The second NAS study examined the socioeconomic effects of increased CO_2 in the atmosphere and emphasized the point that uncertainties in predicting the effects will continue even while intensive research generates more knowledge. The report recommended that "the main energy consuming nations must keep open a number of options for energy and not become committed to an extended period of unrestricted fossil-fuel use." The panel concluded: "[W]e must ensure that options for adaption and prevention remain open."[25]

The DOE Carbon Dioxide Effects Research and Assessment Program continued its long-term efforts to develop the ability to predict the agricultural, environmental, and societal effects of increased atmospheric concentrations of carbon dioxide. In the fifth year (1984) and tenth year (1989) of the Program, comprehensive reports will be issued. The first will evaluate international research efforts and recommend research. Two major workshops to develop

comprehensive research plans were held. The first, held in Miami in 1977, concerned the global carbon cycle and climatic effects of increasing carbon dioxide. The second, held in Annapolis in 1980, concerned environmental and societal consequences of a possible CO_2-induced climate change. The DOE Program summary concluded: "It is the sense of the scientific community that carbon dioxide from the unrestrained combustion of fossil fuels is potentially the most important environmental issue facing mankind." [26]

Although international cooperation in research and planning on CO_2 issues is in a relatively early stage of development, the CO_2 question is beginning to receive increased global attention. U.S. program plans and activities have been reviewed by the United Nations Environmental Programme, and cooperative opportunities appear possible. In September 1980, the International Energy Agency sponsored a meeting of research managers from the Organization for Economic Cooperation and Development nations. There has also been active participation in planning the CO_2-related programs of the International Congress of Scientific Unions. Since 1976, several international meetings have focused on increased atmospheric carbon dioxide. At least two more are planned for 1981.

BIOMASS ENERGY

With rising costs of oil and gas exploration and development, national attention has turned to alternative energy sources. Fuels derived from biomass—diverse plant and animal materials, including forest products and residues, animal manure, sewage, municipal wastes, agricultural crops and residues, and aquatic plants—are attractive because they are both renewable and storable. Storability is an especially desirable property. Most renewable energy technologies, such as solar cells, windmills, and thermal collectors, produce energy only intermittently, and their use therefore requires energy storage. With biomass, storage is much less a problem. Further, because biofuels can be supplied in a gaseous, liquid, or solid form, they can often be made compatible with existing combustion systems.

According to a recent report by the Office of Technology Assessment, in the year 2000, biomass could supply the United States with as few as 4–6 or as many as 12–17 quads.[27] The contribution will depend on a variety of factors, including the availability of crop and forest land, improved crop yields, development of efficient conversion processes, proper resource management, and the level of policy support.

The practice of burning biologically derived fuels is growing rapidly throughout the country. Use of fuelwood for residential heating, for example, is up sharply in many parts of the country, saving nonrenewable energy but also prompting concern in many states and localities about air pollution and fire hazards from wood stoves. Agricultural materials are also being used to produce ethyl

alcohol, which is usually mixed in a one-to-nine ratio with gasoline to produce gasohol. As part of a national effort to help limit petroleum imports, in early 1980 the President initiated an alcohol fuels program which is expected to increase ethyl alcohol production capacity several fold over the next several years, reaching more than six times the January 1980 rate in 1981.

Frequently a residual or byproduct of a primary production process is an economically attractive bioenergy resource—tree scraps from lumber or paper production, residues after harvest, and manure from animal feedlots, for example. Energy "farms" or "plantations" where the biofuel itself is the principal product have been considered.

Growing reliance on bioenergy raises important questions about resource use and environmental impacts. They are associated with both production and end use.[28]

BIOMASS PRODUCTION

Intensive biomass farming and residue collection could increase the already significant environmental problems of water availability, pollution, and topsoil loss (see Chapter 7, Natural Resources, for a discussion of erosion and nutrient loss). Table 6–6 summarizes the significant long-term environmental concerns associated with biomass production, collection, and harvesting.

The substantial land and water requirements for terrestrial biomass energy production could compete with requirements for food and fiber production in some regions. However, data on resource requirements and availability for tree farms and agricultural energy farms are few. Only with region-by-region analyses of land suitability and water availability can the potential of the biofuel resource be estimated with confidence. But it is clear that extensive land-based biofuel production could require several hundred million acres of marginal agricultural and forest land. This use could increase erosion and damage land and water resources through runoff of fertilizers and chemical pesticides and salination and waterlogging from large-scale irrigation. Serious ecological impacts could also result; it could reduce plant and animal ranges, increase risks to endangered species, and possibly eliminate specific ecosystems.

END USE

Environmental problems related to end use of biomass fuels depend on the specific process by which a raw material is burned or converted to a conventional fuel through gasification, liquefaction, anaerobic digestion, or fermentation (see Table 6–7).

Without adequate controls, the combustion of wood and forest residues produces air pollution and ash disposal problems. Particulates are the most important criteria air pollutant produced. Although

Table 6–6

Significance of Long-Term Ecosystem Impacts from Biomass Fuels—Production

Environmental concern	Status (state of knowledge)	Likelihood of a finding adverse to technology development	Environmental risk of proceeding with technology development
Forest residue collection			
Collecting forest residues for use as a fuel will decrease their use as a ground cover. This loss of cover potentially leads to faster runoff, increased soil erosion, laterization, decreased water quality, and destruction of ecosystems sustained by the decaying organic material. The increased erosion leads to higher sediment loads and loss of soil nutrients and organic material, which degrades water quality and changes watershed yields. Environmental benefits may also occur, however, because of fewer fire hazards and less pest buildup.	Higher rates of erosion and accompanying loss of soil nutrients lead to loss of productivity and impair the ability of the land to support future woodlands. Specific quantification has not been done. The increased sediment loads, organic material, and soil nutrients lead to more rapid eutrophication. Limited residue removal schemes may reduce these impacts.	Medium. Topsoil is a nonrenewable resource. Good forestry and conservation practices should help to mitigate the impact. Effective control over large areas may be very costly.	Low. Risk centers around increased cost of control.

Table 6–6 (continued)

Significance of Long-Term Ecosystem Impacts from Biomass Fuels—Production

Environmental concern	Status (state of knowledge)	Likelihood of a finding adverse to technology development	Environmental risk of proceeding with technology development
	Whole forest harvesting		
Whole forest harvesting will intensify erosion; soil deterioration; concern with nutrient replenishment, water quality, water yield, and forest reestablishment; destruction of habitats; and concern with aesthetics. The scale of operation is a significant factor.	Higher rates of erosion lead to loss of productivity. However, removal of logging residues may also reduce the chance of forest fire and help to improve overall air quality. The effect on water quality includes a higher level of pollutants, faster runoff, changes in watershed yields, and increased eutrophication.	Medium. Topsoil is a nonrenewable resource. Good forestry and conservation practices should help to mitigate the impact. Effective control over large areas may be costly and may substantially reduce the amount of biomass that can be harvested.	Low. Risk centers around increased cost of control.
	Agricultural crop residue removal		
Soil erosion caused by the action of wind and water on open farmland following removal of crop residues can lead to increased particulate air pollution; increased sedimentation of surface water supplies; and impaired productivity of exposed cropland due to loss of soil, organic binders, and nutrients.	Increased sedimentation from soil erosion is one of the worst water pollutants in the nation. Information is available from agricultural experiment stations and the USDA on soil erosion as a function of soil type, slope, and degree of protection. Significant research is required to quantify permissible degree of residue removal and control strategies.	Medium. Topsoil is a nonrenewable resource. Its continued loss will lead to an increased need for supplemental nutrients that compete for alternate energy resources. Good soil conservation practices should help to mitigate these impacts. Effective control over large areas may be costly.	Low. Risk centers around increased cost of control.

Silviculture and herbaceous energy farms			
Silviculture and herbaceous energy farms will magnify the environmental concerns of present day agricultural use. The need for large tracts of land for energy use, whether diverted from current food and fiber production or from marginally productive lands, will lead to competition for resources and to severe socioeconomic impacts that could cause serious program delays. Water quality and disturbance of terrestrial and aquatic habitats will cause the most serious environmental concerns. Increased sedimentation, soil nutrients, fertilizers, biocides, dissolved solids, and organic matter from increased erosion will lead to lower water quality and increased eutrophication. Both surface water and subsurface water can be affected. In addition, there will be possible air pollution from fugitive dust, aerially applied pesticides, and fertilizers.	Little or no information is available on the impact of wide-scale intensive cultivation practices envisioned for energy plantations, except that it will parallel in many respects the impact that modern agriculture has had on the environment. The clearcutting practiced on the rotational harvests will disrupt terrestrial habitats. The increased sedimentation and eutrophication will disrupt aquatic habitats.	Medium to high. The regional assessments must be completed to reduce the uncertainty of the adverse finding.	Medium. The required R&D program will identify the conditions needed to support energy plantations. The risk may limit geographical and climatic areas and increase control costs.

Low = 0.1 to 0.3 probability of occurrence.
Medium = 0.4 to 0.6 probability of occurrence.
High = 0.7 to 0.9 probability of occurrence.

Source: Based on U.S. Department of Energy, *Environmental Readiness Document: Biomass Energy Systems*, DOE/ERD–0021 (Springfield, Va.: National Technical Information Service, 1979).

Table 6–7

Significance of Health Hazards from Biomass Fuels—Conversion

Health hazard	Status (state of knowledge)	Likelihood of a finding adverse to technology development	Environmental risk of proceeding with technology development
Emissions from biomass combustion			
The impact of burning biomass is similar to, but less severe than, burning coal. The primary air pollutants are particulates and unburned hydrocarbons. Sulfur oxides are lower than for fossil fuels. High-fugitive dust levels can be formed from constant turnover of storage piles.	The emissions of large-scale wood-fired boilers have been measured, and the necessary control technology has been developed for present standards. The potential hazards of storage pile contaminants are not known.	Medium to high for wood-fired residential heaters. The cost of adequate control may limit the use of these heaters.	Medium. Risk is from large wood burners.
Boiler water treatment chemicals, leachates from ash residues, and biomass storage piles may contain organic acids and minerals that may affect water quality.	The potential for pollution from small residential wood-fired heaters is not known, and control technology is unlikely to be adequate for present standards.	Medium for large-scale wood-fired boilers. The effectiveness of existing particulate control technologies for large wood-fired boilers is in question.	Medium. Risk is from small burners.
Residential wood burners in aggregate may cause more severe air pollution from incomplete combustion. These heaters release carbon monoxide and unburned hydrocarbons, which may include photochemically reactive chemicals as well as carcinogens.			
Residuals from biomass gasification			

Emissions from air pollutants may originate from a process stack, waste ponds, storage tanks, equipment leaks, and storage piles. Pollutants of concern include oxides of nitrogen, hydrogen cyanide, hydrocarbons, ammonia, carbon monoxide, and particulates. Many of the same pollutants will also be found in process water and condensates. In addition, phenols; trace metals; and leachates from biomass storage piles, char, and ash residues may contribute to the degradation of water quality.	The pyrolysis produces potentially toxic gases and oil that may be hazardous to health and safety and to ecological communities. Research is needed to quantify the impact of gasification operations for different feedstocks and various operating conditions.	Medium. Controls could be adopted from the petroleum refining industry, which handles similar types of chemicals and pollutants.	Medium. OSHA standards and the potential for an adverse impact on human health could limit the applications. There could be an increase in cost due to controls.
Residuals from biomass liquefaction			
Liquefaction produces gaseous emissions similar to those from gasification. About half of the sulfur and nitrogen compounds will be left in the oil and char residue. The tars produced by the thermochemical decomposition of organic substances pose a special concern. They are expected to contain polycyclic aromatics, some of which are known carcinogens. Liquefaction produces the most char of all thermochemical conversions. If these chars are not consumed in the process, they will likely be stored in open piles and may contribute to both air and water quality impacts.	Liquefaction produces potentially toxic gases and oil that may be hazardous to health and safety and to ecological communities. Environmental significance of gases and oil from liquefaction has not been analyzed.	Medium. Controls could be adopted from the petroleum refining industry, which handles the same types of chemicals and pollutants.	*Medium.* OSHA standards and the potential for an adverse impact on human health could limit the application.

Table 6–7 (continued)

Significance of Health Hazards from Biomass Fuels—Conversion

Health hazard	Status (state of knowledge)	Likelihood of a finding adverse to technology development	Environmental risk of proceeding with technology development
Air and water pollution from anaerobic digestion			
Odor, hydrogen sulfide, and ammonia gases are the primary contaminants affecting air quality. The effluent contains large quantities of biochemically oxygen-demanding materials, organic acids, and mineral salts. Both surface waters could be impacted by discharge or percolation from settling ponds.	Ongoing research will enable qualification of control costs.	Low. Anaerobic digestion provides the environmental benefit of reducing the problem of disposal of feedlot manures. Control technology is generally known from digester treatment of raw sewage. An adverse finding will relate only to the cost of controls.	Low. Risk is associated with cost of control.
Water pollution from fermentation processes			
The key concern is the potential degradation of water quality. The stillage contains large quantities of biochemically oxygen-demanding materials and mineral salts. Both surface and subsurface waters could be impacted by overflow or percolation from settling ponds.	Fermentation residue from protein-rich feedstocks has proven suitable for livestock refeeding. The stillage from carbohydrate-rich feedstocks is difficult to dispose of due to high biochemical oxygen demand and alkali salt concentration.	Low. Increased treatment requirements are possible.	Low. Risk is to protein-rich feedstocks. High. Risk is to carbohydrate-rich feedstocks.

Low = 0.1 to 0.3 probability of occurrence.
Medium = 0.4 to 0.6 probability of occurrence.
High = 0.7 to 0.9 probability of occurrence.

Source. Based on U.S. Department of Energy, *Environmental Readiness Document: Biomass Energy Systems*, DOE/ERD–0021 (Springfield, Va.: National Technical Information Service, 1979).

standard industrial control technologies such as cyclone collectors and baghouses are generally effective against particulate emissions, these technologies are not economically feasible for residential wood stoves, small commercial boilers, and other small-scale units.

Wood burning also releases small amounts of sulfur oxides in exhaust gases. High concentrations of carbon monoxide can occur under poor operating conditions, such as in wood stoves. The problem should be rare in large well-maintained systems. As shown in Table 6–8, these sources can release comparatively large amounts of pollutants.

Direct combustion of wood also releases more than 100 organic pollutants, some of which are carcinogenic; benzo(a)pyrene is just one example.[29] Definitive studies of health effects from these pollutants have not yet been conducted, but given what is already known about them, there is good reason to be cautious.

The types and quantities of air pollutants released by the direct combustion of nonwood biomass are not well defined, but they are expected to be similar to the pollutants released when wood is burned. This subject needs a great deal more study.

Gasification of biomass produces more nitrogen-containing gases and less sulfur-containing emissions than does coal combustion. Biomass gasifiers chemically combine hydrogen with the biomass to form a combustible gas. These reactions typically require high pressures and temperatures and a hydrogen-rich atmosphere. Liquid wastes from gasifiers contain significant concentrations of phenols, oils, wastes with high biochemical oxygen demand, and other pollutants that must be treated prior to discharge. Special disposal is required for ash residues in order to avoid leaching and subsequent water contamination.

Liquefaction of biomass produces gases similar to those from gasification. The liquefaction process involves a catalytic reaction at high temperatures and pressures. About one-half the nitrogen and sulfur contained in the biomass is left in the oil and char residue. The tars in the char create a special problem because they may well include substances that are carcinogenic.

Manure and municipal sewage can be used to produce methane, the principal constituent of natural gas. The conversion process, known as anaerobic digestion, releases negligible amounts of criteria air pollutants. But exposures to hydrogen sulfide, a poisonous, malodorous gas, are an important workplace concern, requiring special equipment. If the hydrogen sulfide is not removed from the product gas of the digester, sulfur oxides generally form when it is burned. Liquid wastes from an anaerobic digester can be simply and effectively treated to control biological oxygen demand.

By natural fermentation, biomass can also be converted to a liquid fuel—alcohol. The most important environmental concern here is the large quantities of biochemical oxygen-demanding materials and mineral salts contained in the waste products. The waste products

depend, of course, on the biomass feedstock, the fermentation process and culture, and the method of ethanol separation. Some processes produce materials which are valuable additives to animal feed; other materials require extensive treatment before disposal.

HYDROGEN [30]

Most renewable energy sources are intermittent. If they are to be widely used, means must be found to store and deliver the collected energy conveniently. Biofuels are unlikely to be able to meet a major share of future energy demands or eliminate the need for other energy carriers. An energy carrier is the specific form that is used to store or deliver energy to the consumer; petroleum, natural gas, and electricity are the principal carriers in the United States today.

Storing large amounts of electricity—which is the principal output of photovoltaic cells, windmills, hydro dams, and other solar sources—presents economic, environmental, and technical difficulties. For this reason, interest is growing in the use of chemical energy carriers to deliver solar energy to consumers. Hydrogen gas (H_2), which can be burned like natural gas, is a possible energy carrier of the future.

Hydrogen has some special characteristics which make it worth considering as an energy carrier:

- It is abundant. Although it is almost always combined with other elements, hydrogen is one of the most common elements.
- It creates little pollution in burning. Only small amounts of nitrogen oxides and water vapor are released when hydrogen is burned in air. No carbon dioxide, particulates, or hydrocarbons are released.
- Production processes need not involve the direct formation of carbon dioxide if noncarbon-based (solar or nuclear) energy sources are used.

Offsetting these attractive characteristics are some serious disadvantages:

- As a fuel, hydrogen is very costly. It is far from being economically competitive.
- There are some potentially serious safety hazards associated with its transport, storage, and use. Hydrogen-air mixtures are flammable over a much wider range (4–75 percent hydrogen) than natural gas-air mixtures (5–15 percent natural gas).
- Although hydrogen is largely free of pollutants when burned, several of the established and more economic production processes release significant amounts of pollutants, including carbon dioxide.

Fairly large amounts of hydrogen (the equivalent of 1 QBtu per year) are being produced, but for use as an industrial feedstock not as a fuel. The principal method of production is steam-carbon reactors by which a hydrocarbon (usually methane) reacts with

Table 6–8

Emissions from Selected Residential Space Heating, Power Generation, and Transportation Sources

Source	CO lbs/10^6 Btu	NO_x (as NO_2) lbs/10^6 Mtu	SO_x (as SO_2) lbs/10^6 Mtu	B(a)P μg/10^6 Btu	Particulates lbs/10^6 Btu
Residential space heating					
Gas	.02	0.08	.0005	80	0.02
Oil	.04	0.09	0.3–7[a]	900	0.07
Coal	3.5	0.1	0.5–7[a]	2,500,000	0.6
Wood					
Fireplace	3.0	.25	NR	45,000	1.3
Stove	22	.07	.03	135,000	1.2
Power generation					
Coal	NR	NR	NR	20–400	NR
Transportation					
Highway vehicles /50 mi)	2.4 lbs	0.34 lbs	0.02 lbs	50 μg	0.06 lbs

B(a)P = Benzo(a)pyrene.
NR = Not reported.
[a] Takes into account sulfur variability in the fuel.

Source: John A. Cooper, "Environmental Impact of Residential Wood Combustion Emissions and Its Implications," presented at the Wood Energy Institute's Wood Heating Seminar II, Atlanta, Feb. 25–28, 1980.

steam to form hydrogen and carbon dioxide. Because this method uses methane as a feedstock—and methane is a very desirable fuel—it is not of long-term interest for production of hydrogen for use as a fuel. Coal can also be used to produce hydrogen, but the process is much more complex and costly than with methane. Using coal also involves the environmental effects of mining plus the residual pollutants from coal gasification.

Much interest in hydrogen as an energy carrier of the 21st century lies in the intriguing possibility of using water as a feedstock. Hydrogen may be produced by decomposing water using electrical or thermal energy to separate the hydrogen and oxygen atoms. The only commercially proven method for getting hydrogen directly from decomposing water is electrolysis.

The conversion efficiencies—that is, the amount of energy available in the hydrogen compared to the amount of energy put in as electricity—range from 60 to 70 percent. With newer technologies, the figure could rise to 90 percent. But the overall efficiency of conventional power plants is only about one-third. Thus hydrogen produced by electricity generated conventionally would carry only one-third of 60–90 percent, which is 20–30 percent of the original energy value of the fuel which produced the electricity. Because most of the high cost of producing hydrogen is in the cost of the

electrical energy, one possibility is to use electricity generated by conventional power plants in off-peak hours. Another is to use electricity produced sporadically from intermittent energy sources, such as wind and sunlight. The major environmental effects of producing hydrogen with electricity are the same as for generating the electricity.

Water can also be decomposed with thermal energy. At very high temperatures (about 3,600° F or about 1,980° C) water breaks down into hydrogen and oxygen; it will also decompose at lower temperatures (about 1,200° F or about 650° C) through various chemical cycles. These thermal approaches are under development. Their overall energy efficiency is generally much higher than the 20–30 percent achievable with electrolysis, but it is estimated at no more than 55 percent. Potential environmental concerns include release of intermediate reactants and concerns associated with the primary heat source.

Through another process commonly termed "photolysis," solar energy could produce hydrogen directly from water through biological or chemical processes. If an economically competitive photolysis process can be developed, it may prove the most desirable way to produce hydrogen, avoiding most of the environmental and resource problems of other processes.

Assuming that hydrogen can be produced at reasonable costs—still a very large assumption—its importance and practicality as a fuel will depend on how readily it can be transported and stored. Small amounts of hydrogen are now shipped by rail and highway either as a gas under very high pressure or as a super-cooled liquid. These approaches are costly and energy intensive. Gas pipelines would be far more practical for long-distance bulk transport—either new pipelines designed especially for hydrogen transmission or, at least to some extent, existing natural gas pipelines. Hydrogen transmission in gas pipelines could begin with the addition of a small percentage of hydrogen to the natural gas. Existing natural gas storage facilities, for example, depleted gas wells, depleted oil wells, salt mine caverns, and above-ground tanks, could be converted for hydrogen storage.

Even if the problems of storing hydrogen onboard are solved, other nonpetroleum fuels may prove more competitive for use in cars, trucks, and buses. Some possibilities are synthetic gasoline, diesel, or alcohol fuels derived from coal or biomass for use in a more or less conventional engine. Another possibility is use of electric vehicles powered by batteries.

The possibility of liquid hydrogen-powered aircraft has also been considered. Because hydrogen is relatively light, it could have some performance advantages over petroleum: lower energy consumption per seat-mile, less weight, and lower emissions of recognized pollutants. These potential advantages would be greatest for long-range supersonic transport, especially Pacific flights in which the 5,500-mile range approaches the practical limit for conventional supersonic

aircraft. But because of costs a market for the flights may never develop. Even at the more usual range of 4,200 miles for supersonic flights, air travel using fuel derived from coal is likely to cost less than its hydrogen-powered alternative, which would present special safety risks in case of accident.

Another use of hydrogen that may be promising is in heating. Most natural gas burners could use a hydrogen-natural gas mixture with little or no modification so long as the hydrogen was no more than 10 percent by volume. Higher hydrogen concentrations would require major modifications or even replacement of burners.

In summary, so long as fossil energy remains available at reasonable costs, hydrocarbon fuels and electricity will compete for primacy as energy carriers. But if high prices, scarcity, or environmental constraints limit the use of fossil energy, hydrogen may well become competitive with electricity for uses that readily lend themselves to gaseous or liquid fuels.

FOSSIL FUEL ISSUES

OUTER CONTINENTAL SHELF OIL AND GAS

The outer continental shelf (OCS) of the United States currently supplies about 9 percent of the oil and 23 percent of the gas produced in the United States.[31] Although government and industry estimate that 60 percent of the nation's undiscovered oil and natural gas resources may be located in the OCS, exploration in many areas so far has been disappointing. Preliminary DOE estimates of oil and gas production for 1985–95 suggest that the OCS will continue to supply a significant, although relatively small, fraction of energy needs. OCS oil production, excluding Alaska, could increase to roughly 1.25 million barrels per day (about 20 percent of present domestic oil production) by 1995, depending on oil prices. OCS natural gas production is expected to decline to about 1.9 quadrillion Btu (about 10 percent of present domestic production) in 1995.[32]

Estimates of total U.S. undiscovered recoverable offshore oil and gas resources, including Alaska, have been continually revised downward for the last 5 years. The U.S. Geological Survey's latest revised estimates indicate 12.5–38 billion barrels of oil and 61.5–139 trillion cubic feet of gas still to be discovered in all offshore areas.* By way of comparison, current total U.S. domestic production of oil is about 8.6 million barrels per day; production of natural gas is about 20 trillion cubic feet per year.[33] The Survey's 1975 estimates of undiscovered resources were 10–49 billion barrels of oil and 42–181 trillion cubic feet of gas.[34]

* 1 billion barrels of oil = 5.6 quads.
1 trillion cubic feet of natural gas = 1 quad.

In his Energy Message of April 1979, the President directed the Secretary of Interior to increase the OCS acreage proposed for leasing to private companies for exploration.[35] The Department of Energy and the Department of the Interior worked together to select sites and develop regulations. In March 1980, the Secretary of Interior submitted to the President and the Congress the proposed final oil and gas leasing program for the OCS, together with all comments received on the proposal, as required by the OCS Lands Act, as amended.[36] This submission was made 60 days before Interior's final approval of the program. The leasing schedule covers the 5-year period from June 1980 to May 1985. A mixture of lease sales in proven oil- and gas-producing areas and in frontier areas, the program calls for 36 lease sales over the 5 years and provides for entry into 7 new areas where lease sales have not been held. Areas include 11 sites in the Gulf of Mexico, 6 in the Atlantic, 4 off California, 10 off Alaska, and 5 "reoffering" sites. Seven sales will be off Alaska where leasing has not previously taken place. Also included are areas, notably off Alaska, where government and industry estimates indicate the highest resource potential. In June 1980, the final 5-year leasing program was issued by the Secretary of Interior, essentially as proposed.[37] A significant new feature of the program is an annual reoffering. The Department of the Interior will reoffer tracts outside the Gulf of Mexico on which it did not receive bids or for which it rejected bids the previous year.

The leasing schedule is designed to allow sufficient time for Interior to carry out careful environmental analysis and planning and to consult extensively with affected interests before final decisions on individual sales are made. The Secretary of Interior decided to proceed with planning for Alaska and other frontier areas because the lead times available are sufficient for study and consultation before leasing and exploration and later development and production.

The Secretary recognized public concerns about specific areas of the OCS, such as the Beaufort Sea, the Flower Garden Banks in the Gulf of Mexico, Georges Bank, the Arctic pack ice, the steep inclines of the mid-Atlantic continental slope, and California where there are environmentally sensitive areas offshore and air quality problems onshore. Many of the leases scheduled for sale are from undeveloped rural communities. In Alaska, in particular, the affected communities may be boroughs where no coastal zone management planning has been undertaken. (See Chapter 1, The Global Environment, for further discussion.)

The Department of the Interior has begun preparing environmental impact statements (EISs) on the lease sales. For each frontier area, Interior has offered to help develop coastal zone management plans and prepare detailed environmental reports on development and production plans for state and public review prior to approval. The Department will also scrutinize proposed operating technologies.

Under the 1978 OCS Lands Act, as amended,[38] Interior has the right to cancel leases should environmental or technical hazards outweigh potential benefits of development.

EXPLORATION NEAR THE FLOWER GARDEN BANKS [39]

Since 1977, leasing near the Flower Garden Banks—two submerged hills some 140 miles from the Texas-Louisiana line—has caused new concern about the effects of drilling wastes on marine ecosystems. The Flower Garden Banks reach within 66 feet of the surface; among the several dozen similar structures in the Gulf of Mexico, they alone are capped by well-developed and ecologically diverse coral reefs.

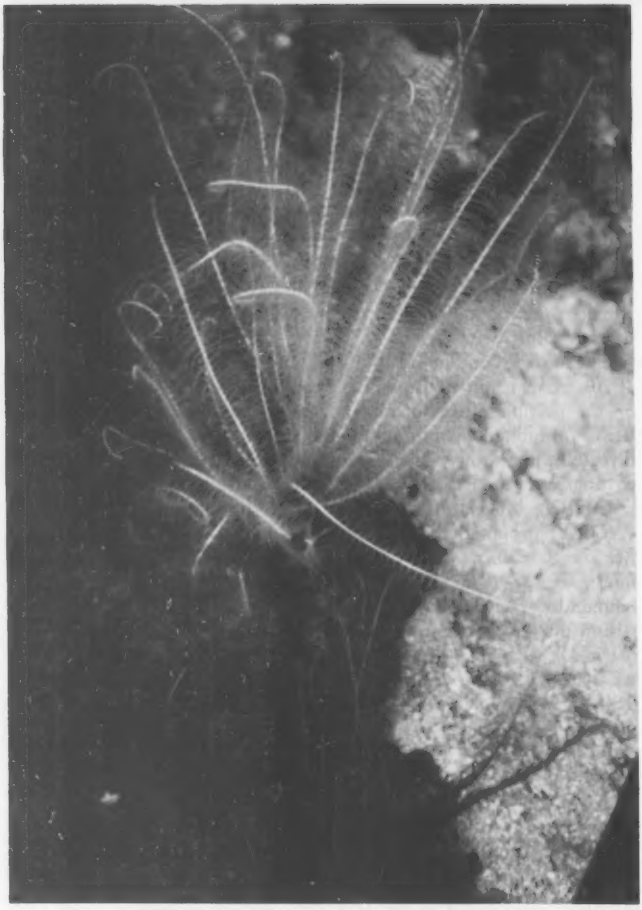
The Banks contain oil and gas, and leasing began in the early 1970s. As a result of Bureau of Land Management-funded studies on the possible effects of oil and gas operations on the coral reefs, BLM prohibited operations on the upper levels of the Banks and directed that at lower levels and in adjacent areas, drilling fluids and cuttings were to be discharged 10 meters above the seabed.

In 1978, the National Oceanic and Atmospheric Administration (NOAA) proposed that the Flower Garden Banks area be made a Marine Sanctuary, with a prohibition on the discharge of drilling fluids within 4.2 miles of the center of each Bank.[40] EPA then recommended prohibition of new source discharges of drilling wastes within the entire sanctuary, based on evidence that they might harm marine life.[41] After discussion with the Department of the Interior, EPA issued final permits in May 1980 prohibiting discharge of drilling wastes on the upper and middle levels of the Banks. A decision on NOAA's proposed Sanctuary designation is not expected until late 1980.

THE UTILITY OIL BACK-OUT PROGRAM

In March 1980 President Carter submitted to the Congress his program to reduce utilities' oil and gas consumption, an initiative originally announced in his July 1979 Energy Message.[42] The Program seeks a reduction of 1 million barrels per day (oil equivalent) by 1990. Phase I would prohibit oil and gas use in specific power plants and would provide $3.6 billion in federal funds to subsidize the conversion to alternate fuels, such as coal or municipal wastes. The Program would make available an additional $400 million for subsidizing scrubbers and coal-cleaning facilities to reduce power plant emissions of sulfur (a principal contributor to acid rain) to levels below those required by the Clean Air Act and State Implementation Plans (SIPs).

Phase II of the Program would provide grants for utilities to reduce oil and gas use by whatever means are cost effective. Utilities would submit fuel displacement plans to their state regulatory au-



Crinoids at the Flower Garden Banks. Feather stars, an ancient group of marine animals, may be threatened by the discharge of toxic chemicals from oil and gas operations (Elliott A. Norse).

thorities and the Department of Energy. The plans would have to consider all reasonable alternatives to oil and include energy conservation, peak-load management programs, and use of solar and other renewable energy sources. A plan must quantify the relative cost-effectiveness of reasonable alternatives, must discuss the reasons for selecting an alternative, and must address in particular the reasons for selecting or rejecting the most cost-effective alternative. State

regulatory authorities must hold public hearings before approving a plan, and background materials used in its preparation and approval must be made available to the public.

A principal objective of Phase II is to encourage utilities to use the most cost-effective means available to reduce their oil and gas consumption. Selection of the most cost-effective alternatives to oil would benefit the utilities, the consumers, national economic growth, total employment, the balance of payments, and national security. The financial and institutional barriers to reducing utilities' oil and gas use would be reduced by this Program.

On several occasions the President has cited the problem of acid rain.[43] Both DOE and EPA agree that the coal conversions subsidized by the Utility Oil Back-Out Program will aggravate the acid rain problem—one which needs the attention of the Congress. The $400 million proposed in the Program for scrubbers and coal cleaning is intended as a first step in solving this major environmental concern.

COAL LEASING

The Secretary of Interior established a new federal coal management program in mid-1979, thus ending an 8-year period of starts, stops, and restarts in federal coal leasing policy.[44] (See the detailed review of this program in the Tenth Annual Report.[45]) Leasing of federal lands for coal mining was suspended in 1971 because few of the lands under lease were being mined and because many people were concerned about the environmental and social impacts of unregulated strip mining, which were not resolved until President Carter signed the Surface Mining Control and Reclamation Act in 1977.[46] Under the new program, federal land is again scheduled to be made available for competitive leasing in 1981.

The Interior program designated four steps for leasing coal lands:

- Land use planning, with public hearings on recommended lands acceptable for coal leasing after consideration of alternative uses
- Preparation of a coal lease sales schedule for each federal coal production region for the coming 4 years and analysis of the schedule in an environmental impact statement, a phase involving states, localities, and the public directly
- Selection by the Secretary of target volumes for each region based on production goals recommended by DOE
- Development of procedures for managing individual coal lease sales.

It is now expected that Interior will lease federal lands containing up to 1.5 billion tons of coal between 1981 and 1982.[47] Several regions have been identified as possible candidates for leasing. In February 1980, the Secretary established a final leasing target of 520 million tons of coal for the Green-River/Hams-Fork region of

Wyoming and Colorado.[48] It is the first federal coal area to be considered under the Department's new management program. Following completion of a regional EIS in August 1980, Interior is expected to decide whether to conduct lease sales within the region in early 1981. Other federal coal production regions where lease sales may be held in 1981 include the Uinta-Southwestern Utah region in Utah and Colorado (322-million-ton target) and the Southern Appalachia region in northern Alabama (tentative 105-million-ton target).[49]

DRILLING THE OVERTHRUST BELT

Not since discovery of the giant oil fields of the Alaska North Slope has there been so much interest in exploring for oil and gas as there is in the Overthrust Belt. This 40- to 50-mile-wide geologic formation extends from Canada to Mexico (see Figure 6–3). Esti-

Figure 6-3

The Overthrust Belt

Source: Philip F. Anschutz, "Rocky Mountain Overthrust Belt Potential," *Gas Energy Review* 8(4):5 (1980) (copyright © by the American Gas Association, Arlington, Va.).

mates of recoverable oil are in the range of 10–15 billion barrels, enough to meet total U.S. oil needs for about 2 years. Gas is estimated in the range of 100–200 trillion cubic feet, 5–10 years' supply at the current rate of consumption.

The Overthrust Belt is an extremely complex geologic structure believed to have been formed when organic sediments were deposited in an ocean trough before the formation of the Rocky Mountains. Partly because of this complexity, gas and oil exploration has been unsuccessful over the decades. "A driller's graveyard," it has been called as one dry hole followed another. Only in the last 5 or 6 years have geologists come to understand the formation well enough to complete a significant number of deeper—and successful—wells.

Oil and natural gas production from the area is not yet significant, but it is expected to increase with accelerated exploration and development. There are already 47 producing wells in Wyoming, where development has been concentrated. Several large processing plants to remove hydrogen sulfide from the natural gas and pipelines to transport the gas to markets are expected to be completed in western Wyoming in the early 1980s.

As often happens, the rapid increase in exploration activity has had a significant impact on small neighboring communities. Evanston, a small town in western Wyoming located near many promising oil and gas fields, has grown about 30 percent from its 1975 population of 5,500 to its present, still growing, population of 7,000. The need for public services is staggering. More than 1,000 new homes were needed to meet the growing needs. Major improvements were also required in water supply, sewage treatment, public safety services, and health care. (See the 1979 Annual Report for discussion of growth and government programs associated with energy development in the West.[50])

Public resistance to oil exploration has developed farther north, near Jackson, Wyoming. Area citizens, who depend largely on tourism and recreation, strenuously object to issuance of two permits for oil and gas drilling on federal lands in the Bridger-Teton National Forest, where more than 2 million acres have been leased. Specifically, it is feared that drilling will lead to construction of access roads into Wilderness Areas, disturbing wildlife and possibly contaminating the watersheds of the Cache and Little Granite Creeks.

In the spring of 1980, the U.S. Geological Survey and the Forest Service announced plans to prepare a joint environmental impact statement covering exploration, development, and production of oil and gas on leased federal lands. Scheduled for completion in September 1981, the EIS will discuss proposed test wells, alternatives to the proposals, including no drilling, and environmental effects. The EIS will help determine where, how, and under what conditions exploration, development, and production may be permitted in parts of the Bridger-Teton National Forest.

NUCLEAR ISSUES

RESPONSE TO THE ACCIDENT AT THREE MILE ISLAND

The March 1979 accident at the Three Mile Island (TMI) nuclear power plant brought the nation dangerously close to a major health disaster. President Carter immediately established a 12-member commission to review the accident and to make recommendations to him. The commission, chaired by Dr. John G. Kemeny, President of Dartmouth College, conducted a 6-month investigation during which it took more than 150 depositions, held public hearings, and collected enough documentation and materials to fill 300 feet of shelf space. The commission reviewed the performance of the utility and its contractors, the training of the power plant operators, the adequacy of emergency evacuation plans, and the responses to the accident by the utility and all levels of government. It also spent a great deal of its time evaluating the overall performance of the Nuclear Regulatory Commission (NRC).

The commission's final report, transmitted to the President on October 30, 1979, was highly critical of both the nuclear power industry and the federal regulatory program designed to police it.[51] Major findings of the commission follow:

- The accident was initiated by a mechanical malfunction and was made much worse by a series of human errors in response.
- The accident revealed very serious shortcomings in the entire government and private sector system that regulates and manages nuclear power. To avoid more serious nuclear accidents, fundamental changes are required in the organization, procedures, practices, and especially the attitudes of the NRC and the nuclear industry.
- The NRC was so preoccupied with the licensing of plants that it had not given adequate consideration to overall safety issues. The NRC had left generic safety issues unresolved for years and had no systematic way of identifying safety problems from the operating experiences at nuclear plants.
- Although the training of power plant operators at Three Mile Island conformed to NRC standards, it was inadequate and contributed significantly to the seriousness of the accident. NRC standards allowed a shallow level of operator training.
- On a number of important issues, the utility owning TMI and the manufacturer of the plant failed to acquire enough information on safety, failed to analyze adequately the information that they did have, or failed to act on it.
- At all levels of government, planning for offsite consequences of nuclear accidents lacked both coordination and urgency. The NRC had not made it mandatory to have a state emergency or evacuation plan.

The commission also concluded that in spite of serious damage to

the power plant, the radioactive releases from the accident would have a "negligible effect on the physical health of individuals." (The major health effect, they concluded, was mental stress associated with the accident.) Examining the potential impact on the 2 million or so persons living within 50 miles of the plant, the commission calculated that over the lifetimes of all the affected individuals, there would probably be less than one extra death from cancer. Over the same period, this population would experience some 325,000 cancer deaths from causes unrelated to the power plant.

A separate study, performed for CEQ, examined the potential long-term health impacts on populations living beyond a 50-mile radius of the plant of the Three Mile Island accident as well as more serious accidents that could conceivably have resulted from the incident.[52] Like the Kemeny report, the study concluded that the number of cancer deaths that might occur in the population far from the plant is negligible. But had the accident been more serious, tens of thousands of extra cancer deaths and genetic defects could have resulted over many decades. The authors of the report concluded that the potential health impacts at large distances from nuclear plants have not been adequately considered and that thyroid protection medicine, sheltering in buildings, and air filters on power plants to remove radioactivity could prove valuable in reducing radiation doses experienced during an accident.

The President stated that he agreed fully with the spirit and intent of the commission's recommendations and would implement them immediately where he had the authority to do so. The President rejected, however, the recommendation to abolish the (now legally independent) NRC and create a new agency with a single head within the Executive branch. Instead, he announced that he would submit to the Congress a reorganization plan to strengthen the role of the NRC Chairman. Under the new organization, the Chairman would have the authority to act as the chief executive officer and to mandate safety requirements and procedures. In addition, the Chairman would be empowered to act on behalf of the NRC during an emergency.

The President also announced the creation of a 5-member Nuclear Safety Oversight Committee.[53] The Committee is to report to the President at least annually on the progress of the NRC, other federal agencies, the states, and the utilities in improving the safety of nuclear power plants and in implementing the recommendations accepted by the President.

To improve emergency planning, the President directed the Federal Emergency Management Agency (FEMA) to assume responsibility for all offsite nuclear emergency planning and response. Supplemental appropriations for FEMA, the NRC, and the Department of Energy were announced to accelerate these changes.

In addition to the Presidential investigation, the Congress and the NRC reviewed the TMI accident. The NRC review, headed by

Washington attorney Mitchell Rogovin and released in January 1980, reached a number of conclusions and recommendations similar to those of the Kemeny report. Specifically, the NRC group recommended an expanded effort to improve and monitor reactor operations and to improve onsite technical and management capabilities.

It is not possible to separate the impacts of Three Mile Island on the future of nuclear power from inflation, reduced growth rates for electricity, and other factors. But it is clear that orders for new nuclear installations are dwindling. In 1978, 2 new nuclear plants were ordered and 12 existing orders were canceled. In 1979 no new orders were placed and 3 units were canceled.[54] In the first 3 months of 1980, 8 units were canceled.[55] According to one review, of the 192 units either built or planned, no more than 166 are likely to operate, and the figure could be as low as 136.[56]

RADIOACTIVE WASTES

In the more than 30 years since the beginning of the nuclear era, ever increasing amounts of radioactive wastes have been generated by national defense programs, by the nuclear power industry, and by medical, industrial, and research activities. Government efforts to manage the wastes have not been technically adequate nor have they successfully involved the states, local governments, and the public in policy and program decisions that affect them.

On February 12, 1980, culminating nearly 2 years of technical and policy review, President Carter announced the nation's first comprehensive radioactive waste management program. The paramount objective of the policy is to protect the health and safety of all. Key elements of the President's program are:

- All levels of government should share responsibility for the safe management and disposal of nuclear wastes. To this end, the President has created a State Planning Council of elected state, local, and tribal officials and Cabinet Secretaries to advise the Executive branch and to work with the Congress on key radioactive waste management and disposal issues. State and federal interaction in siting high-level waste repositories will be based on consultation and concurrence.
- Pending review required by the National Environmental Policy Act, an interim planning strategy for disposal of high-level and transuranic wastes has been adopted that relies on mined geologic repositories. The repository program will be technically conservative and will move carefully, step-by-step, toward site selection and operation of the first high-level waste repository. Immediate attention will focus on locating and characterizing potential repository sites in different geologic environments. When four or five sites are found potentially suitable, one or more will be selected for development as a licensed full-scale repository. The site for the

first full-scale repository should be selected by about 1985, and it should be operational by the mid-1990s.

- The proposed Waste Isolation Pilot Plant project at Carlsbad, New Mexico, will be canceled because it would be unlicensed and unable to accept commercial wastes. The site will be investigated further. If it is found qualified, it will be considered for a licensed repository for high-level wastes.
- Safe interim storage of commercial spent fuel will continue to be a responsibility of the utilities until a permanent respository capability exists. The Administration will continue to press for legislation to build or acquire limited spent fuel storage capacity at one or more away-from-reactor facilities for the utilities which are unable to expand storage and for limited amounts of foreign spent fuel when U.S. nonproliferation policy interests would be served.
- The Department of Energy will work with the states to establish a reliable commercial low-level radioactive waste disposal system.
- The Administration will propose legislation to extend NRC licensing authority to all DOE facilities for transuranic waste disposal and all new DOE sites for disposal of commercial low-level wastes. Under present law, the NRC has licensing authority over DOE facilities only for disposal of high-level radioactive wastes.
- Specific actions will be taken to improve and expedite regulatory action by EPA and the NRC.
- The NRC is determining whether radioactive wastes can be disposed of safely. The President is urging the NRC to make its determination in a timely manner while providing for public, technical, and government participation.[57]

Financing the cost of nuclear waste management and disposal will be based on the principle that the cost should be paid by the generator and borne by the beneficiaries of the activity generating the wastes. Utilities are to pay for storage and disposal of wastes from power plant operations, with costs to be passed on to the customer. The government will pay for storage and disposal of wastes from defense and government research and development activities, with financing from tax revenues.

The President's interim strategy will be implemented by the comprehensive National Plan for Nuclear Waste Management. He has directed DOE to produce the Plan by 1981 and to update it every 2 years. A draft is to be submitted for public review, and a revised draft is to be submitted to the public and the Congress.

NUCLEAR NONPROLIFERATION—THE INFCE AND NASAP STUDIES

The final plenary conference of the International Nuclear Fuel Cycle Evaluation (INFCE) was held February 25–29, 1980, in Vienna, culminating an extensive review of nuclear technology begun in October 1977 at the request of the President. Fifty-six countries

and five international organizations participated. Although the INFCE neither endorsed nor rejected U.S. concerns with reprocessing and breeder reactors, it recognized the possible proliferation risks of reprocessing and other fuel cycle activities.[58]

The INFCE findings reflect a growing international consensus that the economic benefits of reprocessing and recycling plutonium—created by the fission process in light water reactors—are marginal. Plutonium can be chemically separated from spent nuclear fuel and then used in place of uranium to run a conventional nuclear reactor; but once separated, plutonium can also be used to fabricate nuclear weapons. The INFCE concluded that the economic advantage of recycling plutonium is not likely to be large, and it will decrease if uranium continues to be available and the price remains low. This finding is significant in view of the fact that only a few years ago many nations considered plutonium recycling essential to their nuclear power programs. Today not a single country is actively engaging in commercial plutonium recycle. Several countries continue to reserve plutonium recycling as a future option. According to the INFCE report, those who plan to use plutonium consider it mainly for use in fast breeder reactors.

The Nonproliferation Alternative Systems Assessment Program (NASAP) final report, published by DOE in 1980, strongly reinforced the INFCE findings on plutonium recycling and made it clear that this option is uneconomic for the United States and the world in the foreseeable future. Regarding the breeder reactor, which could produce plutonium as an alternative fuel if uranium resources proved inadequate, NASAP concluded that "a worldwide uranium imbalance could occur between 2010 and 2025 unless there were an aggressive development of resources." [59] But "[w]ith even lower projected growth rates, it now appears that an imbalance is not likely before 2025, regardless of whether there is an aggressive development of uranium resources." [60]

Both the INFCE and NASAP reports support the Interagency Review Group conclusion in March 1979 that reprocessing is not an essential step to disposal of spent nuclear fuel.[61]

REFERENCES

1. Energy Security Act, Pub. L. 96–294, 93 Stat. 611 (1980).
2. Crude Oil Windfall Profit Tax of 1980, Pub. L. 96–223, 93 Stat. 229 (1980).
3. Information provided by the Pacific Power and Light Co.
4. Sandra Blakeslee, "Utilities To Offer Array of Costs, Energy Savings," *Los Angeles Times*, Feb. 3, 1980, Part I, p. 1.
5. Burt Solomon, "Windmills Move into the Market," *The Energy Daily*, March 27, 1980, p. 1.
6. Roger W. Sant, Mellon Institute, Energy Productivity Center, *The Least-Cost Strategy: Minimizing Consumer Costs through Competition* (Arlington, Va., 1979).

7. U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, DOE/EIA 035/80(06), June 1980.
8. Information provided by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Asheville, N.C.
9. U.S. Army Corps of Engineers, Institute for Resources and the Hydrologic Engineering Center, *U.S. Army Corps of Engineers National Hydroelectric Power Resource Study*, Vol. I: *Preliminary Inventory of Hydropower Resources* (Ft. Belvoir, 1979), p. 13.
10. Based on an industrial estimate of 1 QBtu of wood energy used by the paper industry in 1979 and a rough estimate of 0.6–1.0 QBtu used in nonpaper industry areas (e.g., home heating, forest products) for 1976. The latter is from David Tilman, *Wood as an Energy Resource* (New York: Academic Press, 1978); Gerald Schreuder and David Tilman, "Wood Fuels Consumption, 1978: Report to U.S. Forest Service" (Washington, D.C., draft, March 1980).
11. Energy Security Act, Pub. L. 96–294, 94 Stat. 611 (1980).
12. Crude Oil Windfall Profit Tax Act of 1980, Pub. L. 96–223, 94 Stat. 611 (1980).
13. Federal Nonnuclear Energy Research and Development Act, as amended, 42 U.S.C. 5901.
14. U.S. Environmental Protection Agency, *Environmental Evaluation*, EPA 600/9–79–020 (Washington, D.C., 1979).
15. U.S. Environmental Protection Agency, *The Federal Nonnuclear Energy Research and Development Act (Public Law 93–577) Section 11 Environmental Evaluation, Report to the President and Congress*, EPA 600/9–80–008 (Washington, D.C., 1980).
16. American Association for the Advancement of Science, "Carbon Dioxide Effects Research Assessment Program," Workshop on Environmental and Societal Consequences of a Possible CO_2-Induced Climate Change (Annapolis, Maryland, draft, April 2–6, 1979); G. M. Woodwell, G. J. MacDonald, R. Revelle, and C. D. Keeling, "The Carbon Dioxide Problem: Implications for Policy in the Management of Energy and Other Resources," prepared for the Council on Environmental Quality (Washington, D.C., 1979); Senate Committee on Governmental Affairs, *Carbon Dioxide Accumulation in the Atmosphere, Synthetic Fuels, and Energy Policy: A Symposium*, 96th Cong., 1st Sess. (Washington, D.C.: U.S. Government Printing Office, 1979). Some of the energy policy issues associated with the CO_2 problem have been discussed at scientific meetings, such as the World Meteorological Organization's Eighth Conference in 1979. A Massachusetts Institute of Technology-Oak Ridge Associated Universities study is beginning to look at CO_2-related policy issues.
17. National Academy of Sciences, National Research Council, Assembly of Mathematical and Physical Science, Geophysics Research Board, Geophysics Study Committee, *Energy and Climate* (Washington, D.C., 1977); J. S. Olson, H. Pfuderer, and Y. J. Chan, *Changes in the Global Carbon Cycle and the Biosphere*, ORNL/ILS–109 (Oak Ridge: Oak Ridge National Laboratories, 1978); U.S. Department of Energy, Carbon Dioxide Research and Assessment Program, "Workshop on Global Effects of Carbon Dioxide from Fossil Fuels" (Washington, D.C., 1979); G. J. F. MacDonald, "An Overview of the Impact of Carbon Dioxide on Climate," M78–79 (McLean, Va.: The Mitre Corporation, 1978). The present concentration of CO_2 is about 335 parts per million. The pre-industrial (about 1800) level is estimated at 260–300 ppm.
18. W. S. Broecker et al., "Fate of Fossil Fuel Carbon Dioxide and the Global Carbon Budget," *Science* 206:409 (1979). The relatively small effect of varying fuel mixtures within a given total fossil fuel use scenario is discussed in W. P. Elliott and L. Machta, *Carbon Dioxide*

Accumulation in the Atmosphere, Synthetic Fuels, and Energy Policy, supra note 16. See also U. Kantzke, "Expanding World Use of Coal," *Foreign Affairs* (winter 1979–80), p. 351.

19. World Energy Conference, Conservation Commission, World Energy: *Looking Ahead to 2020* (New York: IPC Science and Technology Press, 1978); International Institute for Applied Systems Analysis, Energy Systems Group, *Energy in a Finite World*, Vols. I and II (Cambridge, Mass.: Ballinger Publishing Co., 1981). For a sharply differing view of global energy use, see A. B. Lovins, "Economically Efficient Energy Futures," presented at the International Workshop on Energy Climate Interactions, Muenster, March 3–7, 1980.
20. National Academy of Sciences, National Research Council, Assembly of Mathematical and Physical Science, Climate Research Board, *Carbon Dioxide and Climate: A Scientific Assessment* (Washington, D.C., 1979).
21. SRI International, *JASON: The Long-Term Impacts of Increasing Atmospheric Carbon Dioxide Levels*, JSR79–04, prepared for the U.S. Department of Energy (Washington, D.C., 1980); SRI International, *JASON Report: The Long-Term Impact of Atmospheric Carbon Dioxidation Climate*, JSR–78–07, prepared for the U.S. Department of Energy (Washington, D.C., 1979).
22. The possible benefits of enhanced CO_2 levels for agriculture are discussed in S. H. Wittwer, "Environmental and Societal Consequences of a Possible CO_2-Induced Climate Change on Agriculture," presented at the Annual Meeting of the American Association for the Advancement of Science, San Francisco, Jan. 5, 1980.
23. G. J. F. MacDonald, *supra* note 17.
24. National Academy of Sciences, *supra* note 20.
25. Letter from the National Research Council, Assembly of Mathematical and Physical Sciences, Climate Research Board to Dr. Philip Handler, President, National Academy of Sciences, April 18, 1980.
26. U.S. Department of Energy, Office of Health and Environmental Research, Carbon Dioxide and Climate Research Program, *CO_2: Summary of the Carbon Dioxide Effects Research and Assessment Program* (Springfield, Va.: National Technical Information Service, 1979).
27. U.S. Congress, Office of Technology Assessment, *Energy from Biological Processes* (Washington, D.C.: U.S. Government Printing Office, 1980).
28. The discussion which follows is based primarily on the following reports: U.S. Department of Energy, *Environmental Readiness Document—Biomass Energy Systems*, DOE/EDP–0021 (Springfield, Va.: National Technical Information Service, 1979); U.S. Department of Energy, *Environmental Development Plan—Biomass Energy Systems*, DOE/EDP–0032 (Springfield, Va.: National Technical Information Service, 1979).
29. J. A. Cooper, Oregon Graduate Center, "Environmental Impact of Residential Wood Combustion Emissions and Its Implications," 1980.
30. This discussion is based primarily on National Academy of Sciences, National Research Council, *Hydrogen as a Fuel*, Assembly of Engineering, Energy Engineering Board (Washington, D.C., 1979), and on D. P. Gregory and J. B. Panghorn, "Hydrogen Energy," *Annual Review of Energy* 1:279–310 (1976).
31. Information supplied by the U.S. Geological Survey.
32. Information supplied by the U.S. Department of Energy, Energy Information Administration.
33. U.S. Department of Energy, *Monthly Energy Review*, DOE/EIA 0035/80(06), 1980.
34. "Offshore Oil, Gas Estimates Rise Only for Alaska," *Oil and Gas Journal*, March 17, 1980, p. 85.
35. Energy Message, April 5, 1979, *Public Papers of the President of the*

United States: Jimmy Carter, 1979, Book I (Washington, D.C.: U.S. Government Printing Office, 1979), p. 609.
36. Outer Continental Shelf Lands Act, as amended, 43 U.S.C. 1431 et seq.
37. Department of the Interior, Press Release, June 18, 1980.
38. 43 U.S.C. 1431 *et seq.*
39. C. Holden, "Coral Reefs in Potential Conflict with Oil and Gas Development," *Science* 204:812 (1979).
40. U.S. Department of Commerce, "Proposal Designation of the Flower Garden Banks as a Marine Sanctuary" (Washington, D.C., 1978).
41. U.S. Environmental Protection Agency, "Permit Conditions for NPDES Permits at the Flower Garden Reefs, Gulf of Mexico, Outer Continental Shelf" (Washington, D.C., 1978).
42. See "White House Fact Sheet on the President's Import Reduction Program," July 15, 1979.
43. See, for example, the White House, "The President's Second Message on the Environment," *Weekly Compilation of Presidential Documents* 15:1353 (1979).
44. For more details, see U.S. Department of the Interior, *Federal Coal Management Report, Fiscal Year 1979* (Washington, D.C.: U.S. Government Printing Office, 1980).
45. Council on Environmental Quality, *Environmental Quality—1979: The Tenth Annual Report of the Council on Environmental Quality* (Washington, D.C.: U.S. Government Printing Office, 1979), pp. 341–43.
46. Surface Mining Control and Reclamation Act, 30 U.S.C. 1201, Pub. L. 95–87, 91 Stat. 445 (1977).
47. U.S. Department of the Interior, Office of Coal Management and Bureau of Land Management, *Summary—Federal Coal Management Programs* (Washington, D.C.: U.S. Government Printing Office, 1980).
48. U.S. Department of the Interior, News Release, Feb. 6, 1980.
49. U.S. Department of the Interior, Office of Coal Management and Bureau of Land Management, "Federal Coal Management Program: Summary," January 1980.
50. Council on Environmental Quality, *supra* note 45, at 495–98.
51. President's Commission on the Accident at Three Mile Island, *The Need for Change: The Legacy of TMI* (Washington, D.C.: U.S. Government Printing Office, 1979).
52. Jan Beyea, "Some Long-Term Consequences of Hypothetical Major Releases of Radioactivity to the Atmosphere from Three Mile Island," prepared for the Council on Environmental Quality, 1980.
53. Executive Order 12202, March 18, 1980.
54. "1980 Nuclear Plant Survey," *Electrical World*, Jan. 15, 1980, p. 51.
55. *Energy Daily*, March 4 and 25, 1980.
56. *Id.*, March 25, 1980.
57. The White House, "The President's Program on Radioactive Waste Management," Feb. 12, 1980.
58. International Nuclear Fuel Cycle Evaluation, *Summary Volume*, STI/PUB/534 (Vienna, International Atomic Energy Agency, 1980).
59. U.S. Department of Energy, *Nuclear Proliferation and Civilian Power: Report of the Nonproliferation Alternative Systems Assessment Program, Executive Summary*, DOE/NE–1001/1 (Springfield, Va.: National Technical Information Service, 1980), p. 34.
60. *Ibid.*
61. Interagency Review Group on Nuclear Waste Management, *Report to the President*, NTIS–T10–29442 (Springfield, Va.: National Technical Information Service, 1979).

Chapter 7

NATURAL RESOURCES

The nation has long been proud of the richness and diversity of its soil, water, and mineral resources and of its ability to convert these resources into food, fiber, and other marketable products. We have also given increasing attention to the recreational, aesthetic, cultural, and scientific value of these resources in their natural state —as forests, rivers, mountains, and grasslands replete with fish and other wildlife.

Conflicts among these competing uses of the nation's natural resources intensified during the last decade as people began to recognize both the economic and environmental limits of resource exploitation. Nevertheless, a common understanding is emerging from this competition—the need for long-term conservation and management of these natural resources to provide sustained social, economic, and environmental benefits. Although the origins of this theme can be traced back to the first decade of this century, it has been given new relevance by several recent government efforts to assess national and global resources and to project the consequences of current trends. These assessments show clearly that persistent problems such as overgrazing of rangeland, erosion of topsoil, depletion of ground water, loss of wetlands and wildlife, and the increasing scarcity of fossil fuels and other minerals are not amenable to short-term or isolated solution. Rather, longer-range integrated efforts are needed to achieve more efficient management and use of these resources while maintaining environmental quality.

Some conflicts between resource protection and resource development are unavoidable, but in some areas, notably agriculture, the management strategies that are evolving in the 1980s appear to have both economic and environmental benefits.

PUBLIC LANDS

Of the 2.3 billion acres of land within the United States, the federal government manages approximately one-third—775.2 million

acres—acquired primarily during the 19th century by purchase, treaty, and state cession. This wealth of public land is not uniformly distributed. About one-half is in Alaska, and about 90 percent of the rest is in the 11 western states.

These lands are recognized today as a vast storehouse of natural resources and values. Competition among grazing, mining, outdoor recreation, fish and wildlife, timber, water supplies, and wilderness is intense.

Concern with federal land management policies has existed since the 19th century. Policies have changed, but many of the same questions remain—how much land the federal government should retain, for what purposes lands should be managed, and who should decide the priorities—the Congress, the public, the administering agencies, or the states.

Until nearly the end of the 19th century, federal tenure and management of public lands were perceived as temporary. The primary goal of early public land policy was the transfer of land from public to private ownership to encourage settlement and economic growth as the nation expanded westward. As Congressman Orlando B. Ficklin of Illinois stated in 1845:

> Unless the government shall grant head rights, or donations of some kind, these prairies, with their gorgeous growth of flowers, their green carpeting, their lovely lawns and gentle slopes, will for centuries continue to be the home of the wild deer and wolf; their stillness will be undisturbed by the jocund song of the farmer, and their deep and fertile soil unbroken by the ploughshare. Something must be done to remedy this evil.[1]

Numerous laws promoted the disposal of federal land. The Homestead Act of 1862, the Desert Land Act of 1877, the Timber and Stone Act of 1878, and the Stock Raising Homestead Act of 1916 offered free agricultural, grazing, and timber land to settlers. In addition, the railroads were given vast tracts to encourage westward expansion of interstate commerce. The General Mining Law of 1872,[2] in effect today, encouraged prospecting on the public lands by allowing conveyance of title not only to certain minerals but to the surface area as well. As a general rule, the best and most productive public land was claimed first under these early laws and thereby removed from public ownership.

A reaction against abuses of the disposal laws led to a shift in public land policy toward conservation and the permanent retention of some lands as federally managed public lands. The concept of federal protection of environmentally significant land developed in the late 1800s with the establishment of Yellowstone National Park in 1872. The General Revision Act of 1891[3] contained the Forest Reservation provision for millions of acres of federal land to be set aside as National Forests or Parks to preserve their natural values and protect them from "forest raiders."[4] By 1900 six National Parks had been established.

These steps were not taken without controversy. When Presi-

dent Cleveland signed a proclamation reserving 13 additional forests, bringing the total National Forest System to 50 million acres,[5] outraged Senators demanded his impeachment. Bills passed to reverse the proclamation and repeal the 1891 Act were vetoed by the President.

The appointment of Gifford Pinchot in 1898 as the Department of Agriculture's Chief Forester marked the beginning of a fundamental change in the federal management of public lands. Pinchot was largely responsible for the transfer of the administration of the forest reserves from the Department of the Interior to the Bureau of Forestry in the Department of Agriculture in 1905.

In an effort to control the removal of fuel and fertilizer minerals from public lands, the Congress passed the Mineral Leasing Act of 1920, amending the 1872 mining law and creating a permit and leasing system for coal, oil, oil shale, gas, phosphate, and other minerals.[6]

When lands valuable chiefly for timber, minerals, and crops had been claimed by settlers or reserved as forests or parks, much of the remaining public land was useful only for grazing. By 1934, overgrazing and drought had turned millions of these acres into wasteland. A survey revealed that 99 percent of the public grazing land was in a static or declining condition. Both the federal government and the ranchers recognized a need for stricter control. The result was the Taylor Grazing Act,[7] which gave the Secretary of Interior authority to create grazing districts and issue grazing regulations. The Act and subsequent Executive orders effectively closed the remaining public domain to unrestricted settlement, thus bringing the disposal era to an end.

Pinchot's forest management program, the Mineral Leasing Act of 1920, and the Taylor Grazing Act established a policy of active management of public lands.

The Department of the Interior, primarily through the Bureau of Land Management (BLM), the Fish and Wildlife Service, the National Park Service, and the Water and Power Resources Service (formerly the Bureau of Reclamation), administers more than 500 million acres of public lands. BLM has the largest share—450 million acres. The Forest Service in the Department of Agriculture administers another 188 million acres. By law, the lands administered by the Forest Service and BLM are managed for multiple uses, including production of wood, forage, wildlife and fish, water, minerals, historic and cultural resources, recreation, and wilderness.

The National Park System is managed primarily for preservation, the National Wildlife Refuge System for conservation, wildlife, and recreation. The National Wilderness Preservation System is comprised of federal lands managed to preserve wilderness; the National Wild and Scenic Rivers and National Trails Systems provide recreation opportunities on federal, state, or privately owned lands.

The last decade has witnessed the beginning of a new era for public lands, with formalization of long-term multiple-use management through legislation. The growth in demand for natural resources—energy, minerals, and timber—concurrent with rising concern for the quality of the environment, with emphasis on protection, preservation, and non-exploitive uses, has generated increasing conflict. To address these issues, the Congress passed several major statutes in the 1960s and 1970s relating to public land management. The Multiple-Use Sustained-Yield Act of 1960 [8] established the policy that the National Forest System lands would be managed under the principles of multiple use of their natural resources and sustained yield of forest products. Subsequently, the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA),[9] as amended by the National Forest Management Act of 1976 (NFMA),[10] the Federal Land Policy and Management Act of 1976 (FLPMA, the BLM Organic Act),[11] and the Public Rangelands Improvement Act of 1978 [12] reemphasized this policy both for the Forest Service and for the Bureau of Land Management. These statutes established the principle that the management of federally managed forests and rangelands would be based on detailed inventories of the resources, careful planning, and public participation, with the goal of achieving a balance among competing uses.

Concurrently with the growth of the multiple-use concept, the idea that the federal government should set aside lands for special management was also gaining wide public support. By 1964, three major public land preservation systems had been instituted: the National Park System in 1872 [13] (the National Park Service was created in 1916 to supervise the system); [14] the National Wildlife Refuge System in 1966 [15] (the first Refuge had been established by Executive order in 1903);[16] and the National Wilderness Preservation System in 1964.[17] As of 1979, the three systems protected 16.4 percent of the federal lands. Continuing approval for the addition of environmentally significant lands to these systems is demonstrated by their continued growth over the last decade, when 57,035,000 acres were added—an 81.5 percent growth (see Table 7–1).

The National Wild and Scenic Rivers System and the National Trails System are also special management systems.

Controversy and tensions over how public lands should be managed have not vanished with these new policies. In the West, individuals engaged in ranching and in oil, gas, and mineral development have recently launched the "sagebrush rebellion" in reaction to federal restrictions on their access to and use of federal lands. The goal of this movement is to transfer federal lands to the states. Largely as a result of these efforts, the Nevada legislature has claimed title to 49 million acres of BLM-managed land. Arizona,

Table 7–1

Growth of Special Management Conservation Systems, 1969–79

System	Acres (thousands)		Miles (thousands)	
	1969	1979	1969	1979
Preservation systems				
National Park System	29,496	76,721 [a]		
National Wildlife Refuge System	30,540	34,974 [b]		
National Wilderness Preservation System [c]	9,925	15,301		
Other systems				
Wild and Scenic Rivers System			789	2,318
National Trails System				
Scenic Trails			4,450	7,550
Historic Trails			0	9,037
Recreation Trails			0	4,403
Total Trails			4,450	20,990

[a] Includes 42 million acres designated in Alaska in 1979 as National Park Service Monuments by Executive action.

[b] Does not include the 40 million acres withdrawn by Secretarial action or the 11.8 million acres designated as National Monuments by Executive action in 1978 because the areas were not officially added to the Refuge System until 1980.

[c] Includes only Forest Service and Bureau of Land Management lands, which comprise 80 percent of the Wilderness System.

New Mexico, Washington, Utah, and Wyoming have passed similar initiatives.

As BLM continues its efforts to reverse the deterioration of public rangelands, discontent among users of the public lands may continue. Achieving a reasonable balance among competing uses will be difficult, and success in the long run may well depend on broader public acceptance of the need for and benefits of federal land management to maintain and sustain these national assets over the long term.

PARKS, REFUGES, RIVERS, AND TRAILS

Alaska

Alaska covers 375 million acres, more than twice the area of Texas, but its population is less than one-half million. Once entirely federal land, 60 percent of the state is expected to remain under federal management after Alaska and the Alaskan natives complete their selection of lands authorized under the Alaska Statehood Act [18] and the Alaska Native Claims Settlement Act of 1971.[19] The remaining federal lands include the nesting grounds of 40 million seabirds, more than 200 million other migratory birds,

more than 70 percent of the breeding areas of the world's seals and sea lions, and the habitat of countless caribou, moose, wolves, Dall sheep, grizzly bears, and musk oxen. These lands also contain large forests and mineral deposits.[20] Considered by President Carter as the most important conservation issue of his Administration,[21] the protection and management of these lands became the focus of extended debate in the Congress. The conflicts, which include the familiar differences of opinion between developers and environmentalists, also relate to the question of states' rights, fairness to native peoples, and the interests of all Alaska residents.

In 1978, the House of Representatives, seeking a balance between preservation and development, passed the Alaska National Interest Lands Conservation Act, setting aside 102 million acres of Alaska land to be included in the National Forest, National Park, National Wildlife Refuge, and National Wild and Scenic Rivers Systems. A threatened filibuster kept a Senate committee bill from reaching the floor of the Senate.

In the absence of a legislative solution, the Secretary of Interior, under Section 204(e) of the Federal Land Policy and Management Act of 1976,[22] temporarily withdrew 110 million acres from state selection in November 1978. This action was taken to protect the areas from development until the Congress had decided on their management. The President, in December 1978, used his authority under the Antiquities Act of 1906 [23] to designate 17 National Monuments in Alaska, totaling 56 million acres.[24] Most of the National Monuments were in the acreage that had been withdrawn by the Secretary. Designation of an area as a National Monument permanently prevents mining, logging, and other commercial development unless authorized by the Congress.

In 1979, the House once again passed an Alaska lands bill which was endorsed by the Administration. It included protection of entire ecosystems and watersheds while leaving most of Alaska's productive mineral areas open for exploration.[25] It was designed to protect 125.4 million acres of land from development, including the preservation of 68.1 million acres as wilderness.

The Senate Energy and Natural Resources Committee reported out a bill, with provisions to protect 102.2 million acres.[26] It designated as wilderness one-half the wilderness acreage in the House bill; allowed oil and gas exploration in the Arctic Wildlife Range, the calving grounds for one of Alaska's largest caribou herds; and permitted timber harvest and mining in important wildlife areas. It was initially opposed by the Alaska Coalition (a group representing the principal national conservation organizations).[27] The Congress had not resolved its differences by the October 1980 recess.

Concerned with continuing Congressional uncertainty over the Alaska lands legislation, the Interior Secretary again used his authority under FLPMA [28] to extend the temporary withdrawal of 40.12 million acres of Alaska lands for 20 years; [29] their protected status would have expired in 1981.

These protected lands included 12 new National Wildlife Refuges to be managed by the Fish and Wildlife Service and 4 Natural Resource Areas to be managed by BLM. The Arctic National Wildlife Range, whose acreage was increased through withdrawals, was renamed the William O. Douglas Arctic National Wildlife Range "in memory of a great American statesman and environmental leader."[30] The withdrawals allowed existing mining claims to be worked but banned new ones. Mineral leases required approval by the Secretary of Interior, and subsistence and sport hunting was allowed on most of the withdrawn lands, with the exception of the National Monuments.

In late 1980 the Congress passed and the President signed the Senate version of the Alaska lands bill. It supersedes and generally incorporates prior Executive actions taken by the Administration.

National Park Management

Crowding and traffic congestion are a serious problem in some of the more popular parks. The National Park Service proposed a mangement plan for Yosemite National Park in California again in 1980, the fourth time in 12 years. Earlier drafts were rejected in 1974, 1978, and 1979 because of public reaction. Under the new plan, most administrative facilities and housing for about 1,900 concession and Park employees now located within the Park are to be relocated in El Portal, a nearby town.

The Park Service plans to reduce—and eventually eliminate—automobile traffic in Yosemite Valley. The Park Service also plans to reduce the number of overnight lodging units.

The Grand Canyon National Park is also suffering from a large increase in the number of visitors. Between 1967 and 1972, the number of persons floating the Colorado River soared from 2,099 to 16,432. This increase has caused particular problems for Canyon wildlife and vegetation.[31] After 8 years of study, public input, and planning, the Park Service adopted a management plan early in 1980 which establishes use levels, redistributes launching times for trips, and establishes environmental protection regulations so that river travelers will have a minimal and temporary impact on the soils, vegetation, and wildlife. The plan calls for phasing out motorized river craft over a 5-year period. Beginning in 1985, all trips will be oar powered, and only 70 percent will be commercial.

Since 1976, the number of tour boats and cruise ships entering Glacier Bay National Monument has been increasing. At the same time, the number of humpback whales, an endangered species which traditionally feeds in the Bay, declined from 20–25 in 1976 to only 3–4 in 1979. In May 1980, the Park Service, in accordance with recommendations by the National Marine Fisheries Service, issued regulations to limit tour boat use to 1976 levels with the hope that the whales would return.[32] The Park Service also adopted interim

regulations establishing restrictions on small vessels entering the Monument and prohibiting the harvesting of major species upon which the whales feed.[33]

An unresolved issue concerns a proposal by a consortium of Nevada, Utah, and California utility companies which would establish a large coal mine 3 miles from the southern border of Bryce Canyon National Park. The proposed Alton surface mine would be the largest strip mine in the nation, producing approximately 10.5 million tons per year. It would be visible from Yovimpa Point, an overlook within the Park, and could generate enough particulates to reduce visibility from 200 miles to as little as 20 miles.[34] In November 1979, three environmental groups—Friends of the Earth, the Environmental Defense Fund, and the Sierra Club—filed a petition with the federal Office of Surface Mining in an attempt to have the area declared "unsuitable for mining" under Section 522 of the Surface Mining Control and Reclamation Act of 1977.

New National Parks

The Channel Islands National Park, created in March 1979, placed a cluster of five islands off Ventura and Santa Barbara Counties in southern California under federal protection.[35] Two of the smaller islands, Santa Barbara and Anacapa, were part of a National Monument created in 1938. The Channel Islands contain exceptional tidal pools, breeding grounds for six species of seals and sea lions, and the only breeding area for the California brown pelican, an endangered species. The enabling legislation also authorized the National Park Service to acquire land adjacent to Point Reyes National Seashore in northern California and to make additions to other National Parks, including 475 acres for Harpers Ferry National Historical Park in West Virginia.

Wild and Scenic Rivers

The President's 1979 Environmental Message directed the Forest Service, the National Park Service, and the Heritage Conservation and Recreation Service (HCRS) to improve the process for evaluating potential National Wild and Scenic Rivers.[36] A 1978 report from the General Accounting Office (GAO) had concluded that slow and costly studies were preventing the inclusion of many potentially qualified river segments.[37] In response to the President's directive, the agencies developed an accelerated study schedule of 24 months for potential Wild and Scenic Rivers.[38] This schedule should substantially reduce the average study time of 6.5 years, provided funding for the studies is available.

The GAO report also pointed out the fact that the majority of potential wild, scenic, and recreational river areas are given little or no protection against adverse federal actions except those from major water resource projects. The HCRS is compiling a Nationwide In-

ventory to identify rivers that might be included in the System. The Eastern Inventory was completed in 1979, and the Western Inventory is scheduled for completion in 1981. The President directed the HCRS to furnish the Inventory to federal agencies whose actions could affect the quality of a river and its immediate environment and/or its suitability as a Wild and Scenic River.[39] The agencies must consult with the HCRS before taking any action which could foreclose the addition of a river to the System. Each federal land managing agency is also directed, as part of its land use planning and environmental review, to study the Inventory rivers on lands that it manages. If an agency determines that a river qualifies and recommends its inclusion in the National System, the agency will plan its actions in such a manner as to protect the river's natural values pending Congressional consideration.

National Trails

Since establishment of the National Trails System in 1968, four National Scenic Trails (Appalachian, Pacific Crest, Continental Divide, and North Country), four National Historic Trails (Oregon, Lewis and Clark, Mormon Pioneer, and Iditarod), and 257 National Recreation Trails (totaling approximately 2,590 miles in 45 states, the District of Columbia, and Puerto Rico) have been designated.

Establishment of the Channel Islands National Park in 1980[40] added the 3,200-mile North Country National Scenic Trail, extending from eastern New York to the vicinity of Lake Sakakawea in North Dakota.

At the direction of the President, the Forest Service designated more than 145 National Recreational Trails, achieving its goal of two trails in each National Forest. By the end of 1980, other federal agencies will designate at least 75 more National Recreation Trails on public lands other than National Forests.

FORESTS

Forest Management

The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA)[41] requires the Department of Agriculture to assess and inventory the nation's forest and rangelands every 10 years, and every 5 years the Secretary of Agriculture is to recommend to the President a Renewable Resources Program for "management and administration of the National Forest System, for research, and for cooperative state and private Forest Service programs."

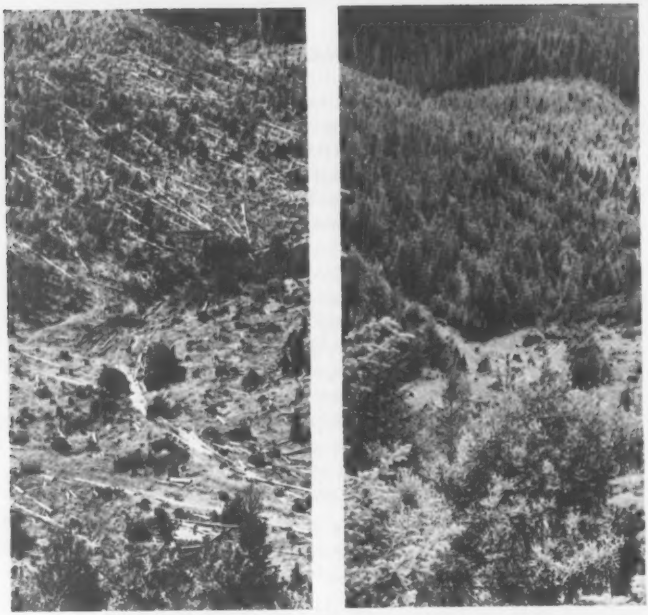
The Program,[42] completed in 1980, was designed to achieve a balance among three important factors—economic efficiency, environmental quality, and the social values related to Forest Service activities. The President noted that "management of both timber and other resources requires ongoing recognition and protection of envi-

ronmental values . . . as an integral part of multiple-use management."[43]

Better management of the nation's natural resources was one of the improvements required by the National Forest Management Act of 1976,[44] which amended the RPA. As part of the NFMA requirements, the Secretary of Agriculture issued land and resource management planning regulations in 1979.[45] They include specific directions on how the Forest Service should prepare management plans at the Forest and regional levels. The new integrated management plans must be completed by the end of 1985 for all 126 National Forest and National Grassland administrative units and for each of the 9 regions. The plans will follow the direction established in the national RPA Program. Public participation and coordination with state and local governments, other federal agencies, and Indian tribes is required during the preparation of all plans.

The land and resource management planning regulations dealt with a number of controversial issues, including clearcutting, protection of waterways, and the rate of timber harvesting. The regulations established the following policies:

- Limitations on clearcutting—a maximum size is established for openings created by timber clearcutting—60 acres for Douglas fir in the Pacific Northwest, 100 acres for Hemlock and Sitka spruce in coastal Alaska, 80 acres for yellow pine in some southern states, and 40 acres for all other forest types. These limits may be exceeded on individual timber sales after 60 days' public notice and review by the Regional Forester.
- Protection of riparian areas—special attention is required for lands and vegetation approximately 100 feet from both sides of all perennial streams, lakes, and other bodies of water. Management practices which would seriously and adversely affect water conditions or fish habitat are not permitted.
- Determination of lands suitable for timber production—economic, physical, and biological factors are to be used as determinants of forest site suitability for timber production and harvesting. Biological growth standards will be established in the regional plans to determine production capability. These standards prohibit commercial harvest until the trees reach the peak of their most rapid growth period. The peak for Douglas fir, for example, may be 80–110 years, depending on the quality of the growing site. Lands with potential for commercial timber production will be evaluated for their economic efficiency, and the most productive lands will be allocated to timber production before the less productive lands. The regulations do not establish guidelines for minimum economic returns from timber sales; nor is there a requirement that sale revenues exceed the Forest Service costs of managing the timber and preparing the sales although some interest groups had pressed for such regulations.
- Departures for nondeclining evenflow—the NFMA regulations



A clearcut area on St. Joe National Forest, Idaho, 6 years after logging and again 16 years after (USDA–Forest Service).

provide for consideration of departure during the forest planning process under prescribed conditions. The nondeclining timber harvest policy of the Forest Service limits the volume of timber sold on each National Forest to levels that can be sustained in perpetuity. In 1979, the President requested that the Forest Service and the Bureau of Land Management evaluate the opportunities for certain temporary departures from this federal policy [46] in order to increase timber supplies for housing, thereby slowing inflation by reducing housing costs. If a departure alternative is selected, it must be consistent with the multiple-use objectives stated in a unit's land management plan. The Forest Service identified 16 National Forests in which planning can be accelerated. Four of the plans were scheduled to be completed in 1980.

Integrated Pest Management

In response to public concern about pesticides, in 1979 the Forest Service added a new chapter on integrated pest management to its basic operating manual (for further discussion of IPM, see the later section on agriculture). Forest Service policy now encourages use of IPM practices—natural controls, selective harvesting, resistant hosts, maintenance of diversity, and removal of damaged trees—in

order to reduce excessive use of chemicals and make forest and rangeland management more efficient.

Before pesticides are prescribed for use on National Forest System lands, biological, environmental, and economic analyses must demonstrate that use of pesticides can achieve specific management objectives. According to the Forest Service, 441,000 acres of National Forest System lands are treated annually with pesticides—170,000 acres with herbicides and 271,000 with other pesticides.

National Forest System Wilderness Review

About 110 million of the 188 million acres of National Forests and National Grasslands have roads; the rest is undeveloped. As of 1977, 15.6 million roadless acres were protected in the National Wilderness Preservation System. Continuing controversy over development versus preservation of the remaining 62 million roadless acres led the Forest Service to initiate its second Roadless Area Review and Evaluation (RARE II) in June 1977.

As a result of RARE II, the Administration recommended that 15.4 million additional acres of National Forest System lands (8 percent of the System) be protected as Wilderness.[47] The Administration also recommended further study of 10.8 million roadless acres and made the balance of 36.2 million roadless acres available for multiple use management other than as wilderness.

The first RARE II wilderness bill to pass the Congress designated as wilderness a 2.2-million-acre section of the Salmon River area in central Idaho.[48] In July 1980, the River of No Return Wilderness became the largest unit of the Wilderness System. The Congress also added 105,600 acres to the existing Selway-Bitterroot Wilderness and designated 125 miles of the Salmon River as part of the National Wild and Scenic Rivers System.

An amendment to the River of No Return bill (the McClure amendment) [49] called for "statutory release" of an adjacent 978,000-acre area set aside by the Forest Service for additional wilderness study. The amendment would have prevented future administrative consideration of the area for wilderness. Although the amendment was rejected 67–21, similar provisions have been inserted in other wilderness bills. In fact, legislative release became the most controversial wilderness issue of 1980.

A federal District Court decision in January 1980, *California* v. *Bergland*,[50] highlighted the RARE II controversy. California, the only state that wanted more of its land designated as Wilderness than the President recommended, challenged the adequacy of the RARE II environmental impact statement (EIS) on 47 roadless areas that were not recommended for wilderness or for further study. The court held that the EIS was inadequate and enjoined further development until the National Environmental Policy Act was complied with. (See the discussion in Chapter 9, NEPA.)

Because the District Court's decision could lead to further court

challenges that would prevent or postpone logging or other development on RARE II lands, the timber industry contends that permanent release provisions, such as the McClure amendment, mentioned above, are necessary to provide some certainty about the long-term uses of the lands not selected for wilderness designation. Opponents argue that such provisions are unnecessary because the future of these lands will be decided through Forest Service land and resource management planning processes. Once a decision is made on how a particular tract is to be used, it is unlikely that that land will be reconsidered for wilderness until revised land management plans are prepared 5–10 years hence.

Mount St. Helens

The May 18, May 25, and June 12, 1980, eruptions of Mount St. Helens sparked debate over future management of the area, which encompasses a part of the Gifford Pinchot National Forest and adjacent state, federal, and private lands. The Forest Service estimates that the initial eruption toppled approximately 3.2 billion board feet of timber.[51]

Trees 175–250 feet long and 3–5 feet in diameter near Mount St. Helens were devastated by the blast and hot gases (pyroclastic flow) (USDA-Forest Service).

A House bill would create a 40,000-acre National Monument in the Mount St. Helens area.[52] The proposed Mount St. Helens Timber Salvage and Mitigation Act would also provide for timber salvage. The Forest Service believes that it already has adequate authority in this area and has assigned a recovery team to determine what part of the devastated area should be preserved for scientific and educational study and what part should be managed for timber production.

Lake Tahoe Basin

Lake Tahoe, situated in the Sierra Nevada Mountains on the border of California and Nevada, is one of the deepest and clearest large alpine lakes in the world. Crater Lake in Oregon and Lake Baikal in the Soviet Union, which are also renowned for their unusual depth and water clarity, are the only other comparable lakes.

Increased population pressures within the Lake Tahoe Basin, however, have contributed to reduced water quality. The overall ecological balance within the Basin is under severe stress as a result of continued residential and commercial development.

Because 71 percent of the land within the Basin is federal land (65 percent is National Forest), the federal government has accepted some responsibility for protecting the Lake from further environmental degradation. In October, the President issued an Executive order to ensure that no federal action is taken that would lead to further environmental deterioration. The order would establish the Lake Tahoe Federal Coordinating Council, to be composed of all federal agencies with responsibilities affecting the Basin. The Council, to be chaired by the Department of Agriculture, would review federal proposals and programs which may affect the Basin and recommend to the responsible agency that it not approve an application if significant adverse environmental impacts would result. In the event of disagreement, the matter would be referred to the Council on Environmental Quality for resolution.

Pending formation of the Coordinating Council, all federal agencies would review proposed programs and actions to determine whether they would significantly stimulate additional development in environmentally critical areas.

The President has urged early enactment of legislation to provide for the sale of federal lands near urban areas in Nevada, with most of the proceeds to be used to acquire environmentally sensitive lands in the Lake Tahoe Basin.[53]

BLM-ADMINISTERED LANDS

Management Processes

The Federal Land Policy and Management Act of 1976[54] established a policy of multiple-use sustained-yield management for the 417 million acres of public land administered by the BLM. This Act requires the BLM to protect and manage these lands in an environmentally sound and cost-effective manner that will reverse the declining productivity of the public range and improve other resources.

The President's 1979 Environmental Message[55] included policy initiatives to achieve the goals set out in the FLPMA. He directed the Secretary of Interior to develop a comprehensive program development process—similar to the Forest Service RPA procedures—for BLM lands.

Shortly after the President's Message was issued, the BLM published regulations establishing the planning system for public lands and resources,[56] as provided for in the Federal Land Policy and Management Act of 1976. These regulations were designed to ensure that actions taken by the BLM were based upon the best available information and sound planning principles. The regulations provide for public participation; an interdisciplinary approach; coordination with other federal, state, and local governments; and use of a systematic planning process. The BLM planning regulations are intended to be consistent with the Department of Agriculture regulations for the Forest Service.

Although resource management planning under FLPMA is just beginning, nearly 80 percent of the public lands administered by the BLM in the 11 western states are covered by existing land management plans known as Management Framework Plans. Ninety-four of these Plans, which were in progress under the old system, will be completed. Implementation of the planning procedures under the new regulations will be phased in over the next 4 years.

FLPMA specifically addressed the complex management problems of the California Desert north and east of Los Angeles. Section 601 describes the California Desert as a "total ecosystem that is extremely fragile, easily scarred and slowly healed . . . . [I]ts resources, including certain rare and endangered species of wildlife, plants, and fishes, and numerous archeological and historic sites, are seriously threatened by air pollution, inadequate Federal management authority, and pressures of increased use, particularly recreation use, which are certain to intensify."[57] In February 1980, BLM released a draft of its Desert conservation area plan alternatives and EIS covering 12.1 million acres. The final plan and EIS were scheduled for release in December 1980.

The California Desert—with its fragile beauty and diverse opportunities for public use (Bureau of Land Management).

A key problem in the California Desert is conflict between the users of motorized vehicles and conservationists over point-to-point cross-country races. Each year, BLM processes more than 100 permits for motorcycle races. Some races are annual events, with as many as 3,000 competitors. BLM is attempting through its California Desert plan to reduce the impact of motorized vehicle use on natural and cultural values of the Desert and thus to reduce user conflicts.

The 1979 Environmental Message also directed the Secretary of Interior to give special attention to protecting BLM lands with nationally significant wildlife, natural, scientific, cultural, or scenic resources. Much of the land administered by BLM contains areas of special cultural and ecological value. One area which is receiving special consideration under this directive is an 81-mile stretch of the Snake River in southwestern Idaho. In April 1980, Interior proposed legislation to establish the Snake River Birds of Prey National Conservation Area.[58] It is believed to have one of the world's greatest concentrations of birds of prey. Among the more than 1,000 raptors that nest there are golden eagles, prairie falcons, and red-tailed hawks. There are also peregrine falcons, an endangered species that is being reintroduced.

Agency Coordination

With enactment of the Federal Land Policy and Management Act of 1976 and the Forest and Rangeland Renewable Resources Planning Act of 1974,[59] as amended by the National Forest Management Act of 1976,[60] BLM and the Forest Service have similar land management and planning responsibilities. The Secretaries of Interior and Agriculture are working together to coordinate their Departments' natural resource policies and programs. Their initial efforts resulted in the establishment of a joint action plan. Staff from both agencies are working together. Task groups are assigned action plan items, specifically: program development; jurisdictional transfers and boundary adjustments; research, energy, and minerals; public involvement; and common policies and procedures for grazing, recreation, wildlife, planning, and environmental coordination.[61]

BLM Wilderness Review

FLPMA's Section 603 directed that public lands managed by BLM be inventoried for wilderness values. By May 30, 1980, inventory of the 174 million acres in the contiguous states had eliminated 124 million acres which were found to lack wilderness characteristics. Approximately 11 million acres were identified as wilderness study areas (WSAs). They will be examined to determine their suitability for designation by the Congress as Wilderness. Final decisions concerning the remaining 39 million acres were to be made by mid-November 1980.[62] Under the Act, BLM must make its Wilderness recommendations to the President by 1991, and by 1993 the Presi-

dent must send his recommendations to the Congress. However, BLM expects to evaluate the WSAs for which there are important resource conflicts—such as energy or mineral resources—by 1984 and to complete study of all the WSAs by 1987.

In December 1979, BLM issued its final Interim Management Policy and Guidelines for Lands under Wilderness Review.[63] The Guidelines require the Bureau to manage the WSAs in such a way as not to impair their suitability for wilderness preservation before the Congress has an opportunity to act upon the President's recommendations. A major point of dispute between wilderness advocates and the BLM was over BLM's interpretation of the statutory language regarding existing mining and mineral leases in wilderness study areas. BLM decided to continue to allow these uses in the "same manner and degree" in which they were being used on October 21, 1976, the date of enactment of FLPMA.[64] Wilderness supporters strongly disagreed with this interpretation of the FLPMA because it would permit these "grandfathered" uses in previously undeveloped areas.[65] The oil and gas industry, on the other hand, disagreed with the Guidelines because they require restoration of any areas that have been disturbed by the time the Secretary of Interior makes his Wilderness recommendations to the President.[66]

Rangelands

The BLM administers 170 million acres classified as rangeland. In addition to providing forage for livestock, these lands provide wood products, water, recreational opportunities, minerals, habitat for wildlife and fish, and wilderness values. Roughly 135 million acres of the public rangelands are considered to be in fair or poor condition. In 1978, the Public Rangelands Improvement Act (PRIA)[67] authorized "an intensive public rangelands maintenance, management, and improvement program" and $365 million over the next 20 years for implementation.

In November 1979, BLM proposed its new rangeland policy in a draft report, "Managing the Public Rangelands"; the objectives are to improve the 135 million acres now in fair or poor condition; to reduce erosion on the 68 million acres in severe, critical, or moderate condition; to stabilize the 80 million acres in slightly eroded condition; and to double annual forage production from 5.6 million tons to 11.2 million tons. Provision is also made for protection of fish and wildlife habitats and threatened or endangered plant and animal species and their habitats.[68]

To meet these objectives, BLM will inventory its lands for grazing capacity and total production potential. With this information, available vegetation can be allocated to various uses.

BLM has incorporated the preparation of site-specific environmental impact statements into its new grazing program. In 1974, in *Natural Resources Defense Council* v. *Morton*,[69] a federal district court found BLM in violation of the National Environmental Policy

Act for failing to prepare site-specific EISs for grazing management decisions covered in allotment management plans. In 1978, an amended court order required BLM to prepare 144 individual environmental impact statements covering all livestock grazing lands within 10 years.[70] Based on these EISs, BLM is now preparing Rangeland Management Program documents describing planned actions to improve rangelands for grazing, wildlife habitat, watershed protection, and other uses.

Development of resource management plans has required BLM to reconsider livestock grazing allocations. The Public Rangelands report stated: "Given the generally unacceptable condition of the Nation's rangelands, it is clear that grazing use will be subject to some adjustment in nearly all of the EIS areas both for domestic livestock and for wild horses and burros where they occur."[71] But improving publicly owned grazing lands presents considerable difficulties. Both narrow economic interests and the tradition of free access to the public lands for private gain stand in the way. In 1978, BLM made some moderate proposals to reduce grazing in 9 of the 144 areas for which EISs are required. Forty-four percent of the grazing allotments were reduced, 14 percent were increased, and 42 percent remained the same. Nevertheless, opposition from affected ranchers was strong. An amendment to the fiscal year 1980 appropriations bill for the Department of the Interior required BLM to keep reductions within 10 percent of the previous year's levels, suspend any reductions larger than 10 percent, and allow ranchers to appeal proposed reductions.[72] This legislation clearly conflicts with BLM's broader Congressional mandate to restore and improve public rangelands.

The Department of Agriculture, which manages 5 percent of the nation's rangeland, has also initiated a new range management policy.[73] USDA plans to increase productivity and improve range quality, which in turn is expected to benefit the livestock industry.

AGRICULTURE

Agricultural management practices profoundly affect environmental quality as well as the long-term sustainable use of land and water for the production of food and fiber. Farming and ranching directly affect more than 960 million acres—some 40 percent of the land area in the United States.[74] Tillage, pest control, and grazing activities may affect water and air quality, fish and wildlife habitat, and energy consumption. As worldwide demands for food and fiber continue to grow, the management practices chosen by farmers will have increasingly important effects on environmental quality. Resource conservation should be an integral part of modern farming. Resource conservation, management practices that produce high crop yields, and profitable farming are compatible.

One of the most serious environmental problems facing U.S. agriculture today is soil erosion, with a concomitant loss of productive

capacity. More than 140 million acres (one-third of the U.S. cropland base) are eroding at rates which threaten productivity. This impact is masked in part by the intensive agricultural use of energy in the form of fertilizers and pesticides. Such practices raise crop yields but result in pollution problems when these materials or their breakdown products are washed or blown from the fields. Scientists, citizens, and federal regulatory agencies continue to debate the net social benefits of some pesticides, animal growth stimulants, irrigation projects, and alternative management approaches that rely on natural biological cycles.

Basic research on environmentally sound yet productive agricultural systems follows many avenues—enhancing the photosynthetic efficiency of plants, breeding the capability to affix nitrogen into cereal crops, developing multiple cropping systems, and discovering more reliable methods to control crop pests. Recently, a particular production system—organic agriculture—has been the subject of considerable scientific interest, including a major study by the Science and Education Administration (SEA),[75] a research branch of the Department of Agriculture. Analysis of alternative farming methods has contributed much to understanding the economic and environmental effects of various combinations of tillage practices, cropping patterns, fertilizers, and pesticides.[76] These practices, in addition to the physical resources used in growing crops or raising livestock, comprise a given farm's production system.

One of the principal strengths of U.S. agriculture is the diversity of production systems in use on farms and ranches. As the cost and availability of land, water, and energy change over time, adjustments in production systems help dissipate upward pressure on food costs and minimize negative impacts on the environment. In the report discussing the findings of the organic farming research project, the USDA states that the production systems used by organic farmers "are also those which have been cited as best management practices . . . for controlling soil erosion, minimizing water pollution, and conserving energy." [77]

The SEA study team found that organic farming can be successful on any scale, from small hobby farms to very large commercial enterprises. The study concluded:

> Contrary to popular belief, most organic farmers have not regressed to agriculture as it was practiced in the 1930s. While they attempt to avoid or restrict the use of chemical fertilizers and pesticides, organic farmers still use modern farm machinery, recommended crop varieties, certified seed, sound methods of organic waste management, and recommended soil and water conservation practices.[78]

CONTINUING FEDERAL EFFORTS TO CONTROL EROSION

The Department of Agriculture and other federal agencies are

giving considerable attention to conservation of soil and water resources. The Soil and Water Resources Conservation Act of 1977 [79] mandated a comprehensive appraisal of the nation's physical resources and conservation programs. This assessment and planning effort, begun at USDA 2 years ago, is seeking to inventory the extent and quality of the nation's agricultural resources; determine the seriousness of resource conservation problems such as soil erosion, ground water overdraft, and nonpoint water pollution; project the capability of the resource base to meet projected food and fiber demand through the year 2030; and develop and compare alternative resource conservation policies and programs.

The inherent erodibility of soils varies by a factor of more than 1,000 between soils in different geographic regions and land classes. Based on the 1977 National Resources Inventory (NRI), the average erodibility of all cropland is 186 times the erodibility of the least erosive cropland. The 1977 erosion rates for four major crops are shown in Table 7–2. On all cropland, about 3 percent of the acres in cultivation yield nearly 20 percent of the total erosion.

Erosion estimates from NRI data assume average weather conditions. Extreme weather events—hard rainstorms or extended periods of drought—may cause far more serious soil loss. June 1974 rainstorms while corn was too short to provide soil cover caused soil erosion of more than 200 tons per acre in Iowa; [80] wind-caused erosion aggravated by drought damaged almost three times as much land in the Great Plains (5.1 million acres) between November

Table 7–2

Acres Eroding, Four Major Crops

Range of erosion [a] (tons)	Crop (1,000-acre units)			
	Corn	Sorghum	Soybeans	Wheat
6–10	17,195	4,441	13,850	14,894
11–15	6,365	2,341	4,170	4,814
16–20	3,104	1,581	2,058	2,198
21–25	1,977	794	1,000	1,528
26–30	1,470	623	767	993
31–40	1,605	898	1,143	878
41–50	887	439	579	367
51–70	1,021	283	621	361
71–100	551	36	316	69
101–150	174	42	190	45
151–200	54	42	46	16
>200	49	10	41	0

[a] Includes sheet and rill erosion nationwide and wind erosion in 10 Great Plains states.

Source: Based on U.S. Soil Conservation Service, "Basic Statistics: 1977 National Resources Inventory" (Washington, D.C., February 1980).

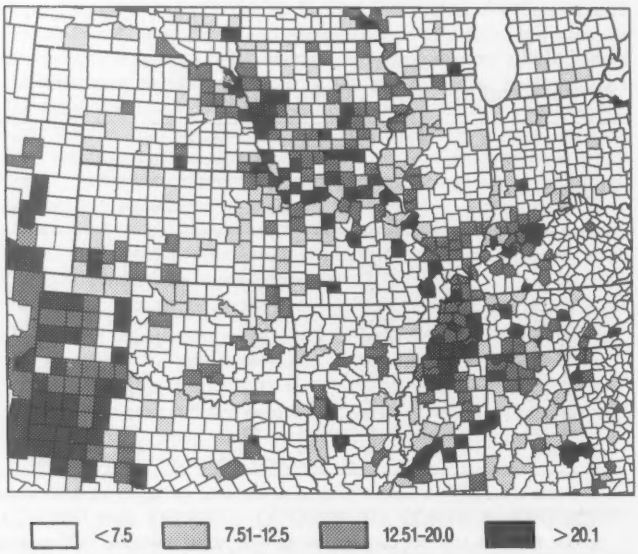
1979 and May 1980 as during the same period in the previous year.[81] In more favorable seasons, gentle and well-distributed rainfall during plant germination and early growth allows the crop to establish a canopy that protects the soil from rain. Once the crop canopy is nearly full, violent rainstorms cause only modest soil loss compared to showers striking bare, cultivated land.

Although areas in nearly every county of the United States erode at high rates, some regions suffer particularly serious erosion, including the Texas High Plains, Puerto Rico, western Iowa, and western Tennessee. One conservation strategy being considered by USDA is to target program funds and personnel to areas where erosion has the most serious impact. For the central United States, the location of counties with serious erosion problems is evident in Figure 7–1.

Based on an analysis of the NRI data, the USDA has again called attention to widespread problems encountered by farmers and ranchers in managing agricultural resources. In addition to providing the most recent data on resource management trends, the NRI categorized the 1.5 billion acres of nonfederal rural land in the United States:

Figure 7-1

Soil Erosion in the Central States



- 413 million acres in cropland
- 548 million acres in grazing land
- 377 million acres in forest land
- 175 million acres in other uses (including urban and builtup areas, highways, and airports).[82]

Among the nonfederal lands, about 346 million acres of prime lands are available for agricultural use. The NRI confirms that sheet and rill erosion control remains perhaps the nation's most pressing resource conservation need. In 1977, erosion averaged approximately 4.8 tons per acre on all cropland in the nation.[83] But in some regions the problem is much more extreme—the six most seriously eroding counties averaged combined sheet, rill, and wind erosion in excess of 100 tons per cultivated acre.[84] In 1977, a nationwide total of more than 1.4 million acres (primarily cotton and sorghum land) were eroding over 100 tons per acre. Fifty-four counties covering 6.2 million acres suffered average erosion rates of 30–100 tons in 1977.[85]

Erosion nearly always reduces soil productivity. Where relatively little topsoil remains, additional erosion lowers crop yields. More generally, erosion increases the cost of producing agricultural commodities. A rule of thumb advanced in the RCA documents is that loss of 1 inch of topsoil—150 tons on 1 acre—generally reduces corn yields between 2 and 3 bushels on that acre.[86] Based on this reduction in yield and assuming corn prices of $3 per bushel, USDA has

Soil erosion in this Iowa cornfield results from planting up and down on the slope rather than on the contour and from removing crop residues from the soil surface (Elliott A. Norse).

estimated that topsoil is worth $0.54–$0.81 per ton based solely on the soil's contribution to crop production.[87]

ENERGY PRODUCTION—PROSPECTS AND PROBLEMS

The nation's need for reliable energy supplies has helped forge a major new farm policy objective: conversion of biomass from the nation's farms and forests to liquid fuels. The most promising near-term application of biomass technologies is the production of ethyl alcohol (ethanol) from corn. When mixed with gasoline in a 1:9 ethanol to gasoline ratio, this product yields the popular new fuel, gasohol. Although attention is focused on farm crops as major biomass feedstocks, any plant material—crops, trees, water plants, even algae and seaweed—could be used in biomass conversion. The President has set an annual alcohol fuel production goal of 500 million gallons in 1981.[88] To reach this target, current plant capacity of 120 million gallons must increase more than fourfold.[89]

A coalition of farmers, civic leaders, and politicians advocates rapid expansion of the nation's gasohol production capacity. Farmers perceive several advantages in gasohol production: by producing energy directly from grain, crop residues, or animal wastes, gasohol offers rural communities a degree of independence from the spiraling costs and unreliable supply of gasoline (also contributing positively to national efforts to solve serious energy supply problems), and, once gasohol production capacity expands, it is a potential positive influence on farm income. The wait for expansion may be relatively short. Ashland Oil and Publicker Industries recently announced plans to construct a 60-million-gallon ethanol plant near South Point, Ohio, projected to consume 6 percent of the entire state's corn crop each year. Another 50-million-gallon ethanol plant may be constructed near Hammond, Indiana.[90]

Many observers question the economic and environmental effects of a massive and rapid change in the use of major farm crops. An important environmental problem associated with energy production from crop residues is that of maintaining soil fertility and preventing excessive soil loss. World nutrition may also be affected if the food needs of the hungry compete with the demand for liquid fuels derived from grain crops.[91]

The full costs of maintaining soil fertility when crop residues are removed for ethanol production are poorly understood and quantified. Nutrients removed by and contained in the crop, including any residues (such as corn stocks or grain straw) removed from the farm, must be replenished by some means if soil productivity is to be maintained. The quantity of nutrients removed in the grain and residue of major crops is substantial. The amount of nitrogen in crop residues alone is about 81 percent of the nitrogen applied in commercial fertilizers to primary crops in Illinois, a major farm state.[92] Table 7–3 shows the quantities of three nutrients contained

Table 7–3

Plant Nutrients Contained in Crop Residues and in Commercial Fertilizer Applied under Conventional Cropping Patterns

Region	Nutrients					
	Amount (1,000 metric tons)			Percentage in commercial fertilizer		
	N	P	K	N	P	K
Midwest						
Illinois	559	74	544	81	40	116
Indiana	272	37	257	84	35	93
Iowa	539	75	515	75	45	153
Minnesota	250	35	276	60	31	113
Missouri	173	21	141	58	29	87
Ohio	189	24	178	72	24	79
Great Plains						
Kansas	217	26	275	42	36	155
Nebraska	230	34	271	44	60	686
North Dakota	96	13	154	70	29	1,250
Oklahoma	59	6	80	31	16	309
South Dakota	72	12	109	80	48	1,000
Texas	180	24	226	27	23	284
Southeast						
Alabama	52	6	37	34	14	43
Georgia	65	8	55	25	14	31
Mississippi	106	12	66	58	37	118
North Carolina	74	10	69	37	16	45
South Carolina	44	5	32	48	18	40
Virginia	48	6	40	59	21	62
Pacific Northwest						
Oregon	16	2	25	17	11	190
Washington	44	5	64	25	18	337

N = Nitrogen.
P = Phosphorus.
K = Potassium.

Source: R.F. Holt, "Crop Residue, Soil Erosion, and Plant Nutrient Relationships," *Journal of Soil and Water Conservation* 34:97 (1979) (copyright © by the Soil Conservation Society of America, used with permission).

in the residues of major crops in selected states and also demonstrates what an extensive resource crop residues are by reporting the quantity of nutrients as a percentage of the commercial fertilizers applied in the states.

The biological process by which crop residues decompose in the soil, providing nutrients to a growing crop, is complex. It is also highly sensitive to a number of natural and human factors. Although the exact tradeoff between residue removal and use of fertilizers can be determined only under specific conditions, farmers would have to increase fertilizer applications substantially in order to maintain soil fertility if crop residues are removed regularly.[93]

Removal of crop residues alters the plant nutrient cycle through a second, less direct mechanism. In nearly all regions, removal of crop residues would exacerbate soil erosion by exposing the soil surface, which would then be more susceptible to wind and water erosion. Scientists have demonstrated that, when crop residues cover one-half the soil surface, the annual rate of erosion on most soils is about 32 percent less than when the soil is bare.[94] Many widely used conservation tillage practices attain or exceed this degree of soil cover. For common midwestern soils, researchers have demonstrated that no-tillage practices maintain up to 95 percent of the soil covered from harvest to corn-planting time the following spring.[95]

A group of Science and Education Administration soil scientists has estimated the impacts of biomass production on soil productivity.[96] The basic question asked was: Under existing cropping patterns and technology, what portion of crop residues can be removed from agricultural land without causing soil erosion more than 5 tons per acre? Their findings indicate that, when optimal conservation practices are applied, an average 58 percent of agricultural residues can be removed without causing erosion over 5 tons per acre.[97]

The nutrient loss through erosion is difficult to quantify precisely. Many factors affect the amounts of nutrients lost from a given field. The timing and methods of fertilizer application affect the portion of applied nutrients that are either used by the crop or carried off the field by eroding sediment or runoff. Soil scientists believe that, on the average, a pound of nutrients lost through erosion or residue removal must ultimately be replaced by a pound from commercial or other sources if production levels are to be maintained.

In estimating total potential nutrient losses from removal of crop residues for biomass conversion, the SEA soil scientists examined erosion rates and nutrient loss for five common tillage systems which allow for different levels of residue removal. Table 7–4 shows the amounts of nitrogen and phosphorus which would be lost under three of the five tillage/residue-retention systems studied. Although the biomass-erosion tradeoff is complex and subject to disagreement about the exact gains and losses involved, Table 7–4 supports two important conclusions. The removal of all crop residues increases nutrient loss 200–300 percent over conservation tillage in which 50 percent of the residue is left on the field (3,500 pounds per acre). The amount of nutrients lost per acre varies widely throughout the Midwest—from as much as 165 pounds of nitrogen in eastern and western Iowa to 28 pounds in south central Minnesota, where erosion is less severe.

Biomass conversion using crop residues would aggravate nonpoint water pollution stemming from agriculture and could aggravate nutrient loss and soil erosion. Streams, rivers, canals, reservoirs, and lakes could be subject to increased sediment loads. Beneficial soil

Table 7–4

Amount of Essential Plant Nutrients Lost under Existing Cropping Patterns for Three Common Tillage and Residue Management Systems

Region	Tillage and residue management system (pounds per acre per year)		
	Conventional [a]	Conservation [b]	No-till [c]
Central Illinois			
Nitrogen	36.8	14.0	8.8
Phosphorus	26.4	12.4	11.4
Western Wisconsin			
Nitrogen	43.2	17.6	12.0
Phosphorus	10.8	4.4	3.0
Eastern and Western Iowa			
Nitrogen	165.6	73.6	63.2
Phosphorus	41.4	18.4	15.8
Southeastern Nebraska			
Nitrogen	56.8	24.4	21.2
Phosphorus	28.4	12.2	10.6
South Central Minnesota			
Nitrogen	28.0	12.8	11.2
Phosphorus	7.0	3.2	2.8

[a] Conventional tillage = Fall moldboard plow with residues removed.

[b] Conservation tillage = Chisel plow with 3,500 pounds of plant residue on the soil surface.

[c] No-till = No tillage, crop planted directly in stubble with 3,500 pounds of plant residue on the soil surface.

Source: Based on M.J. Lindstrom et al., "Tillage and Crop Residue Effects on Soil Erosion in the Corn Belt," *Journal of Soil and Water Conservation* 34:80–82 (1979) (copyright © by the Soil Conservation Society of America, used with permission).

characteristics such as tilth, water-holding capacity, and organic content could also be impaired. Yet because the environmental effects of biomass conversion are diffuse, are indirect, and occur over time, it is difficult to place a monetary value on them.

The SEA study demonstrated that residue available for biomass conversion would be much less in some areas than in others if a minimum level of erosion control were practiced. In regions with flat, deep soils such as north central Iowa, 84 percent of the residue from corn production could be removed for energy production. In eastern Iowa along the Mississippi River, however, only 16 percent of corn residues could be diverted to energy uses without resulting in excessive soil loss.[98]

The factors which determine how much residue could be made available for biomass conversion are the same as those which determine the rate of erosion—degree and length of slope, soil texture, and the intensity of rainfall. Inherent soil erodibility in turn determines the importance of crop residue management to the

control of erosion, except perhaps where other conservation measures (terracing, for example) are in place. More extreme alternatives to control erosion—generally less-intensive cropping patterns or reduction in length or steepness of the slope through land reformation—are economically viable options for only a small portion of the cultivated land base subject to serious erosion. Existing USDA conservation programs can help protect about 10 million acres annually.[99]

RESOURCE CONSERVATION STRATEGIES

Conservation Incentives

The 1977 Soil and Water Resource Conservation Act (RCA) directed the Department of Agriculture to undertake a careful review of agricultural resources. A series of analytic steps was outlined, including monitoring the current state of the resource base, projecting future demands for food and fiber, and reviewing conservation policy options in detail. This series of steps comprises the RCA process. The ultimate objective of this process is to encourage landowners and farm operators to conserve soil, wildlife, and energy resources while satisfying domestic and export demand for basic foodstuffs. Improved land management could also have direct environmental benefits because conservation of farm resources nearly always contributes to the quality of the environment.

The range of public policies and programs encouraging resource conservation has broadened considerably in recent years. Farmers consider voluntary cost-share programs the most acceptable approach. In this type of program, the USDA or a state agency covers a portion, often between 50 and 70 percent, of the costs borne by farmers adopting approved conservation practices. Other strategies may also be justified and effective. For example, several bills before the Congress call for minimum conservation standards (such as limiting erosion to less than 5 tons per acre) as part of a program offering farmers economic incentives to ensure compliance with the standard.[100] As pressure on agricultural resources grows, voluntary programs may prove ineffective or too costly (both to government and to farmers). Then arguments for adopting a mixture of incentives and compulsion might well become more compelling and broadly endorsed. Fortunately, there is a range of options between the voluntary cost-sharing and regulatory program approaches.

Among the resource conservation policy strategies that the USDA is considering, one would require farmers to meet a minimum standard of conservation in order to be eligible for benefits offered through specific USDA programs. Eligibility requirements for commodity price support, cost-share, and loan programs could be included.[101]

One novel incentive under consideration by the USDA is offering a financial bonus to farmers voluntarily adopting sound conservation practices. The bonus could include favorable payment rates in the commodity price support programs or tax advantages.[102] Alternatively, USDA could enter into a contractual agreement with a landowner or farm operator. For agreed-upon financial benefits, farmers would be expected to reduce soil erosion by a given amount through specified conservation practices. Generally, the greater the reduction in erosion, the greater the payment earned by the farmer.

The USDA is also considering the possibility of improving interdepartmental coordination in the administration of its current programs. This strategy would leave the current set of 34 conservation programs basically intact although ways to better coordinate program impacts would be adopted whenever possible.

The federal government might also offer financial and technical assistance to state conservation programs. Transfer of federal responsibility to the states may be possible, depending on their willingness to assume resource conservation responsibilities.

Integrated Pest Management

Encouraging adoption of integrated pest management practices is an important policy challenge. Many farmers now use crop production management systems that establish biologically stable agricultural ecosystems which include soil, plants, pests (at tolerable levels), and natural predators. Both research and practical experience have shown that stable ecosystems can lead to fewer pest problems and to more reliable farm income.[103] In agriculture, IPM strategies are designed to control crop losses by manipulating the relationships between favorable and damaging species within the plant-pest-soil ecosystem. When successful, an IPM control strategy limits crop losses to an economically tolerable level while also minimizing nonessential applications of pesticides.

Because all farms must control a wide assortment of crop pests, policies furthering the use of IPM could have broad benefits for both farm profits and environmental quality. A CEQ report published in late 1979 includes recommendations on ways that federal programs can encourage more rapid adoption of available and proven IPM strategies.[104]

In 1979 President Carter created the Interagency Pest Management Coordinating Committee, chaired by the Council on Environmental Quality.[105] He directed the Committee to review the progress in and barriers to implementing IPM and to oversee coordination of IPM activities by the federal government.

In June 1980, the Committee recommended a national policy on IPM to be implemented by all federal agencies involved in pest control and other IPM-related activities[106]—that the agencies develop and use IPM strategies in their pest control programs whenever technically and economically feasible. The Committee also

identified research and information needs of agricultural, forestry, rangeland, rights-of-way, urban, and public health management programs.

MAKING POLICY WORK—THE ECONOMICS OF FARM PRODUCTION AND CONSERVATION

In the last decade, many farmers found economic justification for adoption of resource-conserving production systems. Over one-third of the erosion-prone rowcrop land in western Iowa is now cultivated with a conservation tillage system. In the last few years, major cotton-producing areas have converted to IPM, spawning many small pest control consulting firms and grower pest control cooperatives in cotton-producing regions. These producer-controlled groups pool resources in administering IPM programs over large areas. Yet in 1979 the total acreage covered by conservation tillage or IPM was small, in some areas insignificant, compared with the acreage for which these measures are available and have proven effective.

When studying the adoption of soil conservation and IPM practices, federal policy analysts question why some producers willingly seek out new production systems while others adhere to older, environmentally damaging practices. Invariably, economic return is the key element in a farmer's choice of a management system. Nevertheless, farmers may place varying emphasis on resource conservation in relation to profit. Because they expect their children to inherit and continue to work their land, some farmers have an enduring interest in preserving soil quality. Under all market situations, they maintain a system which includes an effective conservation component. Farmers with this concern for the land usually choose to make the necessary initial capital investment to install and operate a conservation system, whether it is integrated pest management, maintenance of grassed waterways, or purchase of no-tillage planting equipment.

Other farmers lack such a long-term economic or ethical interest in the land that they farm. Operators who rent land may be most concerned with minimizing per-acre costs and completing field operations over an extensive area as quickly as possible. Such producers might be hesitant to switch from a conventional tillage system (fall moldboard plow, spring disc and harrow, plant)—which allows the farmer to cover a large land area.

Beginning or low-income farmers operating on a small scale without strong financial resources face special problems in conserving their soil and water resources. They may be well aware of the importance of conservation yet lack the financial flexibility to buy the equipment and the technical expertise to carry out the necessary steps in the production process.

There are still other policy questions regarding the relationship between farm size and ownership patterns—the structure of agriculture—and whether farmers adequately conserve basic agricultural resources. A current USDA study, the Structures Policy Project, expects to provide guidance in developing programs which can simultaneously achieve widely embraced farm structure and resource conservation goals.

The regional diversity of both farm structure and conservation needs has been amply documented.[107] Because of the unique problems in a given area, program flexibility to match local needs would be a highly desirable feature of future conservation programs. For farmers already practicing conservation, the main objective would be to help make their operations more profitable. At a minimum, farm policies should not place these producers at an economic disadvantage.

The most serious conflict between conservation and other farm programs occurs with commodity price supports. For example, when a farmer voluntarily idles part of a field in order to use a tillage pattern that conserves soil, the USDA may reduce the size of the farmer's land base eligible for future commodity program participation. In years when the USDA does not require farmers to set land aside as a condition to participation in the commodity programs, farmers are unintentionally encouraged to plant program crops on unstable, marginal land. By doing so, farmers increase the number of acres that can be counted as commodity program acreage. When domestic and world demands slacken, causing USDA to impose a set-aside requirement, farmers can then idle temporarily poor quality land which may not have been brought into production in the absence of the commodity program set-aside provisions.

The set-aside provisions of commodity programs also discourage farmers from applying other beneficial conservation practices. In the Corn Belt, planting legume forages in rotation with rowcrops is a widely recommended conservation practice that yields significant energy benefits to farmers. As much as 100 percent of the nitrogen requirement for corn the following season can be affixed naturally by alfalfa, some clovers, or vetch. The feedgrain program does not specifically prohibit planting these forage legumes on set-aside acreage, but it does require that the forage crop not be harvested or grazed by livestock. Because these provisions prohibit farmers' recovery of any costs of establishing legume cover, they are unlikely to plant legumes, and thus they lose the opportunity to capture conservation and energy benefits. (For further discussion of this issue, see Chapter 8, Human Settlements and Land Use.)

More than 40 percent of U.S. cropland is farmed under some kind of rental or crop-share agreement. This type of farm operation presents a serious obstacle to effective conservation policy. To apply effectively to rented land, a program must either enhance

the perceived short-run profitability of resource-conserving systems or decrease the profitability of conventional tillage systems that contribute to environmental and resource degradation. To date, no program has met this objective.[108]

Smaller or low-equity farmers face different problems. Often they would benefit most from technical and financial assistance in making the initial change to a conservation system. A third set of policy provisions may be required to assist this class of farmers.

WATER RESOURCES

In marked contrast to the severe drought conditions of 1977, heavy rain and snowfall in early 1980 produced adequate to excellent water supplies for most of the western states. Near-record snowpack in parts of Arizona, Utah, New Mexico, and Colorado prompted the National Weather Service to warn of possible floods from snowmelt in this region.[109] Reservoir storage and streamflow in most of the country were near or above normal in May, indicating that water supplies would generally be adequate for hydropower generation, irrigated agriculture, and commercial navigation throughout the summer.

But in July and August, the combination of a recordbreaking heat wave and lack of rain in the central and southern states produced a late season drought that led to substantial losses of corn, soybeans, cotton, and other crops from the Dakotas south through Arkansas to Alabama and Georgia.[110]

Meanwhile, public debate continued over whether both irrigated and dry land agriculture could be threatened during the next 2 decades by competing and growing demands for water for energy and urban development. In January 1980, the General Accounting Office issued a report [111] disputing predictions that insufficient water supplies would be a significant obstacle to energy development in the West and that energy development might create widespread water shortages. Because of slower-than-expected growth in energy demand as well as development of water-saving technologies, energy development is using less water than expected. The GAO suggested that water supplies would be adequate for western energy development through the year 2000 but agreed with the Interior Department and other reviewers of the report that water available for energy development would be severely limited where supplies are already used intensively.

Not all water resource problems can be anticipated. In the Columbia River Basin a major eruption of Mount St. Helens melted glaciers and produced massive mudflows and unprecedented flooding in the Toutle River. Approximately 25 million cubic yards of mud, trees, and other debris were carried downstream into the Cowlitz and Columbia Rivers, disrupting commercial shipping and

reducing the navigation channel in the Columbia from a depth of 40 feet to as little as 14 feet.[112] The Army Corps of Engineers immediately began emergency dredging and clearing operations to restore navigation and to reduce the threat of further flooding. The Congress appropriated more than $200 million in special funds to finance these operations. A task force of federal, state, and local officials was assembled by the Corps to help minimize adverse environmental impacts from the dredging operations. Numerous sites along the Columbia and Cowlitz Rivers will be needed for disposal of several million cubic yards of dredged material; care is being taken to avoid losses of wetlands and wildlife habitat where possible.

IMPLEMENTING THE ADMINISTRATION'S WATER POLICY

The 1979 Annual Report noted that irrigated agriculture accounts for most of the nation's fresh water consumption.[113] In the West, irrigation is the use most likely to conflict with energy development and other potential uses such as maintaining river and stream flows necessary to water quality and the protection of fish and other wildlife. But according to an interagency task force report, improvements in irrigation water management could make several million acre-feet of water available for other uses each year.[114] The report was prepared in response to the President's 1978 Water Policy Message in which he called for new national emphasis on water conservation, improved planning and evaluation to promote only those federal water projects that are economically and environmentally sound, and improved federal-state cooperation in water resources planning and management. The Message and initiatives are summarized in the 1978 and 1979 CEQ Annual Reports.[115]

In June 1980 the Secretary of Interior reported on implementation of the new policy initiatives.[116] Completed actions include:

- Development and use of 11 Presidential policy decision criteria to evaluate federal water projects
- Changes in the Water Resources Council (WRC) Principles and Standards for water project planning to emphasize water conservation and other nonstructural alternatives such as floodplain management in the development of federal water projects
- Publication of a WRC procedures manual requiring accurate and consistent estimation by federal agencies of national economic development benefits and costs for proposed water project alternatives[117]
- Issuance of final regulations to implement the National Historic Preservation Act[118] and publication of proposed regulations to implement the Fish and Wildlife Coordination Act[119]
- Submission to the Congress of proposed legislation to increase state participation in planning and financing federal water projects

- Establishment of an independent review function within the Water Resources Council to review proposed federal water projects for compliance with relevant laws and other planning criteria.[120]

Administrative actions underway as of July 1980 included:

- Promotion of water conservation by the General Services Administration, the Department of Housing and Urban Development, the Environmental Protection Agency (EPA), and other federal agencies at federal facilities and as part of ongoing housing assistance, water supply, and waste water treatment grant programs
- Development of procedures to identify and quantify non-Indian federal reserved water rights (rights to water claimed by the federal government in association with federal lands) in close consultation with states and water users
- Increased federal-state cooperative efforts to assess ground water problems, improve ground water management, and maintain river and stream flows necessary to water quality and the protection of fish and wildlife
- Publication of the WRC Environmental Quality Evaluation Procedures to parallel its national economic development manual to ensure accurate and consistent analysis of the environmental effects of proposed water project alternatives.[121]

The Secretary's report covered Phase I of the implementation effort. Phase II includes continuing work on legislative initiatives such as joint state-federal financing of water development projects and other cost-sharing reforms and on achieving independent water project review, a strengthened Water Resources Council, and other improvements in state-federal water planning and management.

STATE WATER RESOURCES PROGRAMS

According to a 1980 report by the Water Resources Council, state-federal cooperation is limited by the fact that only 29 states have clear legislative or administrative authority to conduct comprehensive water resources planning.[122] Even in the states with such authority, water quality and water quantity programs are often administered by separate, inadequately integrated government units. In only a few states, notably Delaware and Florida, are planning and management unified in a single agency. The WRC report stated that the lack of state legislative and administrative authority limits the states' ability to manage such serious problems as ground water overdraft and pollution, floodplain management, erosion and sedimentation in surface waters, and drainage and dredging of wetlands.

State-federal cooperation is especially important to the solution of ground water depletion and pollution problems. EPA is currently working with the states on a national ground water strategy as a framework for state and federal action. (See Chapter 3, Water Quality, for further discussion of ground water problems.)

WETLANDS PROTECTION

The protection of wetlands—coastal and fresh water—from draining, dredging, and filling is an important national concern. The many benefits of wetlands include production of commercial fish and shellfish, waterfowl, and hardwoods; habitat for diverse wild plants and animals; filtration of pollutants from surface waters; and dissipation of flood waters. These functions are discussed in a federal interagency task force report, *Our Nation's Wetlands*, issued in 1979.[123] Data from several wetlands surveys suggest that approximately one-third of the original wetlands in the contiguous 48 states have been converted to marinas, vacation homes and lots, airports, industrial plants, parking lots, highways, and other uses.[124] Alternative locations may often have existed, but there was no state or federal requirement that they be considered.

Under Section 404 of the Clean Water Act,[125] the Corps of Engineers is responsible for regulating the placement of dredged or fill material in waters of the United States, which include many wetlands. Although the Congress amended the Act in 1977 to allow transfer of portions of this regulatory program to the states,[126] no state has formally sought the authority, but by 1979, 15 states had adopted separate legislation regulating development or other uses of wetlands.[127]

The Corps regulates the discharge of dredged and fill material through its Section 404 permit system. This regulatory program has significantly protected some of the nation's most threatened coastal and inland wetlands. Although specific data on the number of acres affected are not available, in most regions, permit-related activity has increased. Table 7–5 indicates an increase in the number of 404 permits processed—both permitted and denied—and in the number of enforcement actions taken by the Corps.

CONGRESSIONAL ACTIONS

The 96th Congress resolved one controversial water resources issue in 1979 but continued to debate several others in 1980.

Both houses agreed on an energy and water resources appropriations bill [128] that generally met Administration requests. The bill included funds for the Water Resources Council (although not for the independent review function) and deleted funds for a number of water projects opposed by the President. But a last minute addition directed the Tennessee Valley Authority to complete the Tellico Dam on the Little Tennessee River. By this action, the Congress set aside provisions of the Endangered Species Act[129] and the unanimous finding of a special Cabinet-level committee[130] that the project was uneconomical and would destroy the critical habitat of the snail darter, a small fish on the Endangered Species List. In signing the bill, the President sought to avoid a divisive veto battle which

Table 7–5

Regulatory Activities by Region, Fiscal Years 1978 and 1979

Region	Year	Permits				Violations	
		Total * permits issued	404 permits issued	Total * permits denied	404 permits denied	Total * enforcement actions taken	404 enforcement actions taken
Lower Mississippi Valley	1978	2,393	286	7	0	105	36
	1979	2,491	357	9	2	201	111
Missouri River	1978	785	248	2	0	235	32
	1979	873	167	4	4	643	88
North Atlantic	1978	2,413	288	41	3	547	100
	1979	2,028	172	31	4	783	83
New England	1978	589	151	4	1	201	13
	1979	442	105	7	2	209	43
North Central	1978	2,378	777	24	13	354	139
	1979	2,384	587	79	42	693	320
North Pacific	1978	1,074	137	3	2	247	59
	1979	1,013	169	4	3	169	35
Ohio River	1978	1,247	163	11	5	435	102
	1979	1,467	216	10	0	499	194
Pacific Ocean	1978	63	12	3	0	73	14
	1979	55	8	2	0	47	14
South Atlantic	1978	2,528	216	85	13	691	174
	1979	2,305	266	78	16	912	260
South Pacific	1978	584	87	25	6	496	120
	1979	690	102	21	4	543	165
Southwest	1978	2,160	116	9	4	135	82
	1979	2,045	131	2	0	204	105
Total	1978	16,214	2,481	214	47	3,519	821
	1979	15,793	2,280	247	77	4,903	1,418

* Includes Section 404 permits, permits pursuant to Section 10 of the Rivers and Harbors Act of 1899, and permits pursuant to a multiple authority (e.g., a Section 10 and Section 404 combined). The Section 10 and multiple authority permits occur in or physically affect traditionally navigable waters.

Source: U.S. Army Corps of Engineers.

could have affected other important pending legislation, including reauthorization of the Endangered Species Act, which passed later.

Bills to authorize many new water resources projects were developed in late 1979 and early 1980. Both S. 703 and H.R. 4788 contained scores of new projects and other provisions which conflicted with Administration water policy and with established Executive branch planning and review procedures. Many of the proposed projects lacked complete planning documents and environmental impact statements and appeared to provide no net economic benefits to the nation. As of July 1980, H.R. 4788 had passed the House and was being considered by the Senate Environment and Public Works Committee. The President has publicly stated his opposition to the House-passed bill.[131]

Congress debated the role of the Water Resources Council while considering several authorization bills. Since 1965 the WRC has been the coordinator of federal water resources development planning and the primary federal liaison with state and regional water resource planning agencies. Under consideration were bills to reauthorize the WRC as presently constituted with eight federal members, or with an independent chairman and only four other voting members (Agriculture, Army, EPA, and Interior).[132] Other provisions would establish a state advisory committee, authorize an independent review function, and expand the WRC state grant program for planning and technical assistance.

Another controversial legislative issue was whether to relax the acreage limitations of the 1902 Reclamation Act.[133] The Act was originally intended to encourage family farming in the arid West. It authorized delivery of water from federal projects at low cost to irrigate not more than 160 acres of land held by a landowner plus 160 acres for each immediate family member. For years the Bureau of Reclamation (now the Water and Power Resources Service, WPRS) had delivered water at subsidized rates to larger farms as well, but a federal court directed the Interior Department to enforce the Act's acreage and residency requirements more strictly.[134] This decision in turn prompted large western farm operators to seek repeal of these requirements.

As of July 1980, the Senate had passed a bill increasing the limitation to 1,280 acres, and the House was debating the merits of another bill.[135] Although proponents argued that small irrigated farms were not profitable, a Water and Power Resources Service study showed that farms as small as 160 acres are viable and that 90 percent of the beneficiaries of the Service projects (which serve about 9 million acres) owned no more than 320 acres.[136] The WPRS study also found that less than 1 percent of the farmers benefiting from the Service projects control about 19 percent of the irrigated land and that subsidies to project beneficiaries ran as high as $1,787 per acre. The Administration strongly opposed both bills on grounds that

they would undermine the Reclamation Act and unnecessarily subsidize irrigators of large farms.

MINERAL RESOURCES

THE COSMAR STUDY

Environmental and economic impacts of various mining and reclamation technologies for minerals other than coal were evaluated in a major study released in 1979. The study report, *Surface Mining of Non-Coal Minerals*, was prepared by the National Academy of Sciences Committee on Surface Mining and Reclamation (COSMAR).[137] The study was mandated by the Surface Mining Control and Reclamation Act of 1977 to "assist in the establishment of effective and reasonable regulation of surface and open pit mining and reclamation for minerals other than coal."[138] This requirement resulted from Congressional debate over whether the regulatory provisions of the Act, which as written apply only to coal, could reasonably be extended or modified to cover surface mining for copper, uranium, phosphate, oil shale, sand, gravel, and other minerals. Among the principal findings of the COSMAR report were:

- The stated purpose of the Act—to protect society and the environment from the adverse surface effects of mining—can generally be met for noncoal minerals using available technology.
- Some provisions of the Act would be economically or technically impractical if applied uniformly to regulate the mining of other minerals because of the diverse location and nature of noncoal mineral deposits and mining methods and processing.
- There are alternative regulatory mechanisms and other institutional approaches such as land use planning and technical assistance which could ensure the most beneficial postmining land use for areas affected by surface and open pit mining.

The report classified mining for noncoal minerals in two major categories: first, large mining operations limited to specific regions and of national economic importance (e.g., copper, phosphate, iron, molybdenum, uranium, oil shale) and, second, small mining units in all the states and primarily of local importance (e.g., sand and gravel, stone, limestone). Although both groups are responsible for alterations to land, air, and water, the diversity in ecosystems, mining technologies, and minerals makes it difficult to prepare generic environmental regulations for all noncoal minerals.

Although most mining wastes can be controlled by conventional methods, some operations (uranium, phosphate, oil shale, and lead) produce solid, gaseous, and liquid wastes that are difficult to control with existing technology. Identified as major environmental problems were sediment, fugitive dust, release of toxic materials, radio-

activity, tailings containment, and organic and inorganic air pollutants.

The COSMAR report concluded that reclamation would have a better chance of success if an integrated postmining land use plan were developed prior to mining. Unfortunately, the costs of reclamation are often difficult to estimate because of insufficient information and inadequate technology. In the absence of federal reclamation standards for noncoal minerals, local, state, and regional governments must take responsibility for developing resource management policies. There are major problems with existing government controls, particularly "reclaiming disturbed land for anticipated postmining uses, balancing mining against other land uses, and protecting land from abuses under provisions of existing mining laws."[139] Alternative government control techniques for mining and reclamation discussed in the report are education and technical assistance, economic incentives, regulation for specific postmining effects, regulation of the practices that produce specific postmining effects, and public ownership of surface rights.

The Council on Environmental Quality will evaluate these approaches and the comments received at public hearings in developing specific recommendations for consideration by the President and the Congress, as required by the Surface Mining Control and Reclamation Act.

PHOSPHATE

World phosphate rock demand is projected by the Bureau of Mines to rise from its 1978 level of 125 million tons to 365.3 million tons per year by 2000.[140] The United States is currently one of the world's leading suppliers of phosphate rock. If U.S. production is stepped up to meet increased world demand, environmental problems associated with the mining and processing of phosphates will increase unless resource management policies are improved. Mining and processing of phosphate require vast quantities of water, can scar the landscape, and release radioactive radium and radon gas into water and the air.

Because many of the U.S. phosphate reserves are on public lands administered by the Forest Service or the Bureau of Land Management, the federal government has the opportunity to consider how this resource is to be developed and to what extent the environmental costs are controlled.

Florida's Osceola National Forest contains substantial phosphate reserves. The federal government acquired most of this land under the Weeks Act of 1911[141] for timber production and wetlands protection. The BLM is responsible for issuing mineral leases on the land, although the Forest Service must first approve the leasing terms.

Between 1963 and 1968, the Department of the Interior, with the

approval of the Secretary of Agriculture, issued 92 permits to prospect for phosphate on the Osceola National Forest. By 1969, four companies had filed 41 applications for preference right leases based on their prospecting efforts. These applications cover 52,000 acres—34 percent of Osceola—the majority of the land in the western half of the Forest.[142]

Whether to grant leases is a decision to be made by the Department of the Interior. EPA and the state of Florida have opposed issuance of the leases on environmental grounds, stating that the leases would not be in the public interest because phosphate mining in the Osceola Forest might well result in the permanent loss of 28,000 acres of wetlands and productive forest. Such a loss would be contrary to purposes for which the land was initially acquired.

Phosphate mining could have other adverse effects, including drawdown of the artesian Floridian aquifer system, increased levels of radon and radium, and increased sediments in surface waters, including the Suwannee River. In addition, large bermed "slime ponds" would be constructed either within or adjacent to the Forest and would contain thousands of acre-feet of phosphate clay slurry produced during extraction. EPA referred this controversy to CEQ, stating that the proposed leasing alternatives being considered by Interior were environmentally unsatisfactory.[143]

After discussions among representatives of CEQ, Interior, EPA, and the Forest Service, the Secretary of Interior announced that the Department would support legislation which

- Precludes phosphate development in the Osceola National Forest
- Directs the Secretary of Interior to determine whether any lease applicants are legally entitled to phosphate mining leases; if so, the lease rights would be exchanged for leases covering minerals on other public lands, or, if no exchange were possible, compensation would be paid.[144]

REFERENCES

1. Congressional *Globe*, 28th Cong., 2d Sess., XIV, 52 (1845).
2. 30 U.S.C. §§ 22–76.
3. General Revision Act of 1891, 16 U.S.C. § 471.
4. Stuart L. Udall, *The Quiet Crisis* (New York: Holt, Rinehart and Winston, 1969), pp. 100–101.
5. Proclamation, Grover Cleveland, Nos. 19–31, 29 Stat. 893–911.
6. Mineral Leasing Act of 1920, 30 U.S.C. § 181 *et seq.*
7. Taylor Grazing Act of 1934, 43 U.S.C. §§ 315–315n, 315o–1.
8. Multiple-Use Sustained-Yield Act of 1960, 16 U.S.C. §§ 528–531.
9. Forest and Rangeland Renewable Resources Planning Act of 1974, 16 U.S.C. 1600–1614.
10. National Forest Management Act of 1976, Pub. L. 94–588, 90 Stat. 2949 (1976), codified in scattered sections of 16 U.S.C.
11. Federal Land Policy and Management Act of 1976, Pub. L. 94–579, 90 Stat. 2743 (1976), codified in scattered sections of 7, 16, 40 U.S.C.

12. Public Rangelands Improvement Act of 1978, Pub. L. 95–514, 92 Stat. 1803 (1978), codified in scattered sections of 16 and 43 U.S.C.
13. 16 U.S.C. § 1a–1.
14. *Id.* § 1.
15. *Id.* § 668dd.
16. Executive Order 1014 (1903).
17. 16 U.S.C. §§ 1131–1136.
18. Alaska Statehood Act, 48 U.S.C. § 21.
19. Alaska Native Claims Settlement Act of 1971, 43 U.S.C. §§ 1601–1628.
20. White House Press Office, "Alaska Lands Endangered Again," April 26, 1979, p. 2.
21. *Id.*, p. 5.
22. Federal Land Policy and Management Act of 1976, 43 U.S.C. § 1714(e).
23. Antiquities Act of 1906, 16 U.S.C. § 432.
24. Proclamation No. 4611–4627, 43 Fed. Reg. 57009–57119.
25. H.R. 39, 96th Cong., 2d Sess. (1979).
26. *Ibid.*
27. Sierra Club, *National News Report,* November 5, 1979, p. 1; *Audubon Leader,* November 16, 1979, p. 1.
28. 43 U.S.C. § 1714(c).
29. U.S. Department of the Interior, news release, February 12, 1980.
30. Proclamation No. 4729, 45 Fed. Reg. 14003 (1980).
31. National Park Service Fact Sheet on the Proposed Colorado River Management Plan for Grand Canyon National Park, November 1, 1979.
32. 45 Fed. Reg. 32228–32234 (1980) (to be codified in 36 C.F.R. Part 7).
33. 45 Fed. Reg. 32234–32236 (1980) (to be codified in 36 C.F.R. Part 7).
34. "IIP Builders Receive Go-Ahead for Utah Power Plant," *Public Land News,* January 10, 1980.
35. Pub. L. 96–199, 90 Stat. 67 (1979).
36. Message to the Congress, Environmental Priorities and Programs, *Weekly Compilation of Presidential Documents* 15:1365 (1979).
37. U.S. Comptroller General, "Federal Protection of Wild and Scenic Rivers Is Slow and Costly" (Washington, D.C.: U.S. General Accounting Office, 1978).
38. U.S. Department of the Interior, Memorandum to the Chairman of the Council on Environmental Quality Concerning Accelerated Study Schedule for Wild and Scenic Rivers, December 20, 1979.
39. *Weekly Compilation of Presidential Documents* 15:1365 (1979).
40. National Parks and Recreation Act of 1978, as amended, Pub. L. 96–199, 94 Stat. 67 (1980).
41. Forest and Rangeland Renewable Resources Planning Act of 1974, 16 U.S.C. §§ 1600–1614 *et seq.*
42. U.S. Forest Service, "A Recommended Renewable Resources Program 1980 Update," September 1980.
43. Letter to the Speaker of the House and the President of the Senate Transmitting a Statement of Policy and Related Documents, Renewable Resources of the United States, *Weekly Compilation of Presidential Documents* 16:1145 (1980).
44. National Forest Management Act of 1976, 16 U.S.C. §§ 1600–1614 *et seq.*
45. 44 Fed. Reg. 53928–53999 (1979).
46. Separate Memoranda for the Secretaries of Agriculture and Interior from the President, June 12, 1979.
47. The White House, Office of the White House Press Secretary, "State-

ment of the President," April 16, 1979.
48. Central Idaho Wilderness Act of 1980, Pub. L. 96–312.
49. River of No Return Wilderness, S. 2009 Amendments Nos. 647 and 648.
50. *State of California* v. *Bergland,* 483 F. Supp. 465 (E.D. Cal. 1980), on appeal, Ninth Cir. No. 80–4101.
51. Hearing on Status of Volcanic Activity on Mt. St. Helens and the Effects of the Eruptions before the Senate Committee on Commerce, Science, and Transportation, 96th Cong., 2d Sess. (1980).
52. H.R. 7454, 96th Cong., 2d Sess. (1980).
53. *Weekly Compilation of Presidential Documents* 16:1012–1013 (1980).
54. Federal Land Policy and Management Act of 1976, Pub. L. 94–579, 90 Stat. 2743, codified in scattered sections of 7, 16, 40 U.S.C.
55. *Weekly Compilation of Presidential Documents* 15:1353–73.
56. 44 Fed. Reg. 46387–46388.
57. Federal Land Policy and Management Act of 1976, 43 U.S.C. § 1781(a)(2).
58. Cecil D. Andrus, Secretary of Interior, Memorandum to Speaker of the House of Representatives, April 1, 1980.
59. Forest and Rangeland Renewable Resources Planning Act of 1974, 16 U.S.C. §§ 1600–1614 *et seq.*
60. National Forest Management Act of 1976, 16 U.S.C. §§ 1600–1614 *et seq.*
61. Report to the President, Coordination of Natural Resource Programs of the Departments of the Interior and Agriculture, February 6, 1980.
62. 45 Fed. Reg. 47247 (1980).
63. U.S. Bureau of Land Management, "Interim Management Policy Guidelines for Lands under Wilderness Review" (Washington, D.C., 1979).
64. *Id.* Ch. I, Sec. 86.
65. The Sierra Club and Wilderness Society, *BLM Wilderness: A Citizens Handbook,* No. 7 (San Francisco: Sierra Club, 1980).
66. *Public Land News* 5(1):3–4 (1980).
67. Public Rangelands Improvement Act of 1978, 43 U.S.C. §§ 1901–1908.
68. U.S. Bureau of Land Management, "Managing the Public Rangelands," draft (1979).
69. *Natural Resources Defense Council* v. *Morton,* 388 F. Supp. 829, 7 ERC 1298 (D.D.C. 1974).
70. *Natural Resources Defense Council* v. *Andrus,* 448 F. Supp. 802, 11 ERC 1523 (D.D.C. 1978).
71. U.S. Bureau of Land Management, *supra* note 68, at 15.
72. U.S. Congress, House, 96th Cong., 1st Sess., *Making Appropriations for the Department of the Interior and Related Agencies,* Conference report to accompany H.R. 4930, Rep. No. 96–604, p. 8 (1979).
73. U.S. Forest Service, "An Assessment of the Forest and Rangeland Situation in the United States," January 1980, p. xiii.
74. U.S. Department of Agriculture, [*RCA*] *Appraisal 1980: Review Draft Part II* (Washington, D.C.: U.S. Government Printing Office, 1980), pp. 7–29 to 7–32; U.S. Department of Agriculture, National Soil Erosion-Soil Productivity Research Planning Committee, "The Influence of Soil Erosion on Soil Productivity—Science and Education Administration Viewpoint" (Washington, D.C., 1980).
75. U.S. Department of Agriculture, Study Team on Organic Farming, *Report and Recommendations on Organic Farming* (Washington, D.C.: U.S. Government Printing Office, 1980).
76. *Id.* p. xii.
77. *Id.* p. xiv.

78. *Id.* p. xii.
79. Soil and Water Resources Conservation Act of 1977, U.S.C. §§ 2001–2009.
80. Kenneth Grant, "Erosion in 1973–1974: The Record and the Challenge," *Journal of Soil and Water Conservation* 30(1):29–32 (1975).
81. U.S. Department of Agriculture, news release 590–80, March 19, 1980.
82. U.S. Department of Agriculture, *Summary of [RCA] Appraisal, Parts I and II, and Program Report: Review Draft 1980* (Washington, D.C.: U.S. Government Printing Office, 1980), p. 3.
83. *Id.* p. 7.
84. Data were developed by the Conservation Incentives Study staff, composed of representatives of the U.S. Department of Agriculture and the Council on Environmental Quality. The basic data source was the computer tape used in the preparation of U.S. Soil Conservation Service, *Basic Statistics: 1977 National Resources Inventory*, revised (Washington, D.C., February 1980).
85. *Ibid.*
86. U.S. Department of Agriculture, *supra* note 82, at 18.
87. *Ibid.*
88. The White House, "Statement by the President on Alcohol Fuels Program," press release, January 11, 1980.
89. Robert Bergland, Secretary of Agriculture, statement before the U.S. National Alcohol Fuels Commission, June 19, 1980, p. 1.
90. American Farm Bureau Federation, *National Environmental Resources Report* (Park Ridge, Ill., 1980), p. 3.
91. Lester Brown, *Food or Fuel: New Competition for the World's Cropland* (Washington, D.C.: Worldwatch Institute, 1980).
92. R.F. Holt, "Crop Residue, Soil Erosion, and Plant Nutrient Relationships," *Journal of Soil and Water Conservation* 34:97 (1979).
93. *Ibid.*
94. L.L. Slonekar and W.C. Moldenhauer, "Measuring the Amounts of Crop Residue Remaining after Tillage," *Journal of Soil and Water Conservation* 32:231 (1977).
95. *Id.* p. 233.
96. M.J. Lindstrom, S.C. Gupta, and W.E. Larson, "Effects of Residue Removal and Tillage Systems on Soil Erosion and Nutrient Loss in the Corn Belt," an Agriculture bulletin describing a SEA research project on residue availability for biomass production (available from the Science and Education Administration-Agricultural Research, U.S. Department of Agriculture, St. Paul); also reported in W.E. Larson, "Crop Residues: Energy Production and Erosion Control?" and seven related research reports in *Journal of Soil and Water Conservation* 34:74–98 (1979). The reports have been reprinted by the Soil Conservation Society of America, 7515 N.E. Ankeny Road, Ankeny, Iowa, Special Publication 25.
97. M.J. Lindstrom et al., *supra* note 96, at 8.
98. *Id.*, Table 12.
99. Calculated from RCA figures on expenditures on soil conservation programs and from U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, *The Agricultural Conservation Program, 1978 Program Year* (Washington, D.C., 1978).
100. See, for example, H.R. 7022, "The National Soil Conservation Act of 1980," and H.R. 6732, "Special Areas Soil Conservation Act of 1980."
101. Charles Benbrook, "Integrating Soil Conservation and Commodity Programs: A Policy Proposal," *Journal of Soil and Water Conservation* 34:160–67 (1979).
102. U.S. Department of Agriculture, *supra* note 85, at 4–37. See also Charles Benbrook, "An Examination of the Fledgling Alliance of Soil

Conservation and Commodity Price Support Programs," *North Central Journal of Agricultural Economics* 2:1–16 (1980).

103. G.A. Carlson, "The Long-Run Productivity of Insecticides," *American Journal of Agricultural Economics* 59:543–48 (1977).
104. Dale Bottrell, *Integrated Pest Management* (Washington, D.C.: U.S. Government Printing Office, 1979), p. 107.
105. Council on Environmental Quality, *The President's Environmental Program, 1979* (Washington, D.C.: U.S. Government Printing Office, 1979), p. 26.
106. "Report of the Interagency IPM Coordinating Committee" (Washington, D.C.: Council on Environmental Quality, 1980), p. 20.
107. U.S. Department of Agriculture, *Structure Issues of American Agriculture* (Washington, D.C.: U.S. Government Printing Office, 1979).
108. Comptroller General of the United States, *Report to Congress: A Framework and Checklist for Evaluating Soil and Water Conservation Programs* (Washington, D.C.: U.S. Government Printing Office, 1980).
109. U.S. Department of Agriculture, press releases, 576–80, March 14, and 844–80, April 22, 1980.
110. William Robbins, "Severe Drought Withers U.S. Crops in Blow to Farmers and Consumers," *New York Times,* September 12, 1980, p. 1; Alex Mercure, Assistant Secretary of Agriculture, statement before the Senate Committee on Agriculture and Forestry, September 16, 1980.
111. U.S. Comptroller General, *Report to Congress: Water Supply Should Not Be an Obstacle to Meeting Energy Development Goals,* CED–80–30 (Washington, D.C.: U.S. Government Printing Office, 1980).
112. U.S. Geological Survey, *Water Resources Review,* May 1980, p. 11; information provided by the U.S. Army Corps of Engineers.
113. Council on Environmental Quality, *Environmental Quality—1979: The Tenth Annual Report of the Council on Environmental Quality* (Washington, D.C.: U.S. Government Printing Office, 1979), p. 379.
114. U.S. Department of the Interior, *Irrigation Water Use and Management* (Washington, D.C.: U.S. Government Printing Office, 1979), p. ix.
115. Council on Environmental Quality, *supra* note 114, at 387; Council on Environmental Quality, *Environmental Quality—1978: The Ninth Annual Report of the Council on Environmental Quality* (Washington, D.C.: U.S. Government Printing Office, 1978), pp. 282–88.
116. U.S. Department of the Interior, "Final Report on Phase I of Water Policy Implementation" (Washington, D.C., June 1980).
117. 44 Fed. Reg. 72892 (1979).
118. National Historic Preservation Act of 1966, 16 U.S.C. § 470.
119. 36 C.F.R. Part 800, 44 Fed. Reg. 6068 (1979); 44 Fed. Reg. 29300 (1979).
120. Executive Order 12113, "Independent Water Project Review," 44 Fed. Reg. 1955 (1979).
121. 45 Fed. Reg. 64366 (1980).
122. U.S. Water Resources Council, *State of the States: Water Resources Planning and Management* (Washington, D.C., 1980), p. II–2.
123. *Our Nation's Wetlands: An Interagency Task Force Report* (Washington, D.C.: U.S. Government Printing Office, 1979).
124. *Id.,* p. 49.
125. Federal Water Pollution Control Act of 1972, 33 U.S.C. § 1251 *et seq.*
126. Clean Water Act of 1977, 33 U.S.C. § 1344.
127. *Our Nation's Wetlands, supra* note 123, at 53.
128. Pub. L. 96–69, 93 Stat. 437 (1979).
129. Endangered Species Act of 1973, 16 U.S.C. § 1451 *et seq.*
130. 44 Fed. Reg. 3547–48 (1979).
131. President Carter, Statement at the Second Environmental Decade

Celebration, The White House, February 29, 1980.

132. S. 2559, S. 1639, H.R. 2610, 96th Cong., 2d Sess., 1980. See also Interstate Conference on Water Problems, "News in Brief," May 9, 1980.
133. Reclamation Act of 1902, 43 U.S.C. § 371 *et seq.*
134. *National Land for People, Inc.* v. *The Bureau of Reclamation et al.*, 417 F. Supp. 449 (D.D.C. 1976). See also 42 Fed. Reg. 43044–43049 (1977).
135. S. 14, H.R. 6520, 96th Cong., 2d Sess., 1980. See also U.S. Environmental Study Conference, *Weekly Bulletin,* Washington, D.C., June 16, 1980, p. C13.
136. U.S. Department of the Interior, *Interim Report—Acreage Limitation, Executive Summary,* May 19, 1980.
137. National Academy of Sciences/National Research Council, *Surface Mining of Non-Coal Minerals: A Study of Mineral Mining from the Perspective of the Surface Mining Control and Reclamation Act of 1977* (Washington, D.C., 1979).
138. Surface Mining Control and Reclamation Act of 1977, 30 U.S.C. 1299 (1977).
139. National Academy of Sciences, *supra* note 137, at xxvi.
140. W.F. Stowasser, "Phosphate Rock," preprint from the U.S. Department of the Interior, *Facts and Problems, 1980 Edition,* U.S. Bureau of Mines Bulletin 671 (Washington, D.C.: U.S. Government Printing Office, 1980), p. 19.
141. The Appalachian Forest Act of 1911, 16 U.S.C. §§ 513–518 (1979), commonly known as the Weeks Act.
142. U.S. Department of the Interior, final environmental impact statement, *Phosphate Leasing on the Osceola National Forest, Florida* (Washington, D.C.: U.S. Government Printing Office, 1974), p. I–1.
143. Letter from Russell E. Train, Administrator, U.S. Environmental Protection Agency, to Russell W. Peterson, Chairman, Council on Environmental Quality, December 31, 1974.
144. U.S. Congress, House, *Providing for the Wilderness Designation of Certain Lands within the Ocala National Forest, the Osceola National Forest, and the Apalachicola National Forest, and for Other Purposes,* H. Rept. 96–1088 To Accompany H.R. 5431, 96th Cong., 2d Sess., 1980, Section 5.

Chapter 8

HUMAN SETTLEMENTS AND LAND USE

Until recently most people assumed that productive land and coastal resources would last indefinitely. But now, as the nation enters the 1980s, recognition of several serious problems suggests questions about the ability of the land to support the people in the years ahead. One of these problems is desertification—the spread of desert-like conditions to areas that were more productive. If this trend continues, it could seriously reduce high agricultural productivity in both irrigated and non-irrigated lands and lessen the capacity of the arid lands to support human settlements and wildlife.

A second disturbing national trend is the continuing loss of agricultural lands to urban, water resource, transportation, and other development. At present rates of conversion, the nation would lose approximately 60 million acres of agricultural land to other uses by the year 2000,[1] and vast areas of highly productive land could be taken out of cultivation at the same time that less productive and highly erodible land is farmed.

Basic shifts in the nation's demographics—its pattern of human settlement and growth—may be aggravating both these resource problems. The first shift is the population movement westward and southward which has accelerated in recent years.

A second population shift that is significantly affecting the ability of the land to support the people is the continuing movement of the population to the suburbs and a newer movement back to rural areas. Both these shifts have often led to unwise and costly settlement in hazardous floodplains, valuable coastal areas, rich farmlands, and other unsuitable areas.

The 1979 Annual Report discussed efforts being made to conserve coastal resources.[2] This year, the chapter on land use focuses on the concern that continued population growth, shifts of population and patterns of settlement, rising energy costs, increasing soil erosion, and possible leveling off of agricultural productivity could seriously reduce available U.S. agricultural resources by the end of the century.

GROWTH TRENDS

The 1970s witnessed a slowing of growth for the population as a whole, the continuation of some demographic trends, and some reversals, notably the migration to rural areas throughout the country. Trends include movement to the suburbs, movement from the North and East to the South and West, and development in floodplains and coastal areas. Each of these trends has long-term impacts on the nation's environment and resources.

NATIONAL TRENDS

The total population grew 8.3 percent (17 million people) from 1970 to 1979, compared to 13.3 percent for the previous decade. The population reached 221 million by January 1980, having grown nearly 2 million during the previous year.[3]

Rapid growth of the suburbs, which began in the 1950s, continued through the 70s. Although the non-military, non-institutional population as a whole grew 7.8 percent in the decade, as shown in Table 8–1, the suburbs grew 14.3 percent. In fact, they now house nearly 40 percent of the total population. Blacks and Hispanics accounted for a larger share of suburban growth than in the past, constituting 2.9 million of the 10.6 million increase in suburban population between 1970 and 1979.

Nonmetropolitan population grew 11.4 percent, exceeding the national growth rate and nearly doubling the rural growth rate of the 1960s.

By contrast, inner city areas lost population; they had grown 6.5 percent during the 1960s.

REGIONAL POPULATION TRENDS

Population continues to move from the populous, industrialized Northeast and North Central states to the South and particularly to the West. Changes in state population are shown in Table 8–2. California, Texas, and Florida led the nation in growth between 1970 and 1979, each adding more than 2 million residents. Arid regions of the Southwest are among the most rapidly growing in the country. Nevada, Arizona, and Wyoming had the highest growth rates during the 1970s—44 percent, 38 percent, and 35 percent, respectively.

These trends have reached their peak. Florida's growth rate was substantially reduced in the latter half of the 1970s—from 21.5 percent between 1970 and 1975 to 7.4 percent between 1975 and 1979. Arizona's rate declined somewhat, from 23.9 percent in the first half of the decade to 11.9 percent in the second. Arizona is one of nine states whose population grew more than 500,000 since 1970; the

Table 8–1

Populations of the United States by Metropolitan-Nonmetropolitan Residence, Race, and Spanish Origin, 1979 and 1970

Race and residence	1979 [a]	1970 [b]	Change, 1970–79	Percentage change		Average annual percentage change [d]	
				1970–79	1960–70 [c]	1970–79	1960–70 [c]
All races							
Metropolitan areas [e]	145,382	137,058	8,324	6.1	16.6	0.7	1.5
In central cities [f]	60,565	62,876	−2,311	−3.7	6.5	−0.4	0.6
Outside central cities	84,817	74,182	10,635	14.3	26.7	1.5	2.4
Nonmetropolitan areas	69,927	62,761	7,166	11.4	6.8	1.2	0.7
Total	215,309	199,819	15,490	7.8	13.3	0.8	1.3
White							
Metropolitan areas [e]	123,064	118,938	4,126	3.5	14.0	0.4	1.3
In central cities [f]	44,814	48,909	−4,095	−8.4	0.1	−1.0	—
Outside central cities	78,250	70,029	8,221	11.7	26.1	1.2	2.3
Nonmetropolitan areas	63,016	56,338	6,678	11.9	7.8	1.2	0.8
Total	186,080	175,276	10,804	6.2	11.9	0.7	1.1

Black							
Metropolitan areas [e]	19,110	16,342	2,768	16.9	31.6	1.7	2.7
In central cities [f]	14,151	12,909	1,242	9.6	33.2	1.0	2.9
Outside central cities	4,960	3,433	1,527	44.5	26.4	4.1	2.3
Nonmetropolitan areas	5,994	5,714	280	4.9	—5.3	0.5	—0.5
Total	25,104	22,056	3,048	13.8	19.7	1.4	1.8
Spanish origin [g]							
Metropolitan areas [e]	10,145	7,409	2,736	36.9	NA	3.5	NA
In central cities [f]	6,045	4,646	1,399	30.1	NA	2.9	NA
Outside central cities	4,100	2,764	1,336	48.3	NA	4.4	NA
Nonmetropolitan areas	1,909	1,578	331	21.0	NA	2.1	NA
Total	12,055	8,988	3,067	34.1	NA	3.3	NA

NA = Not applicable.

[a] Five-quarter annual averages centered on April from the current population survey.

[b] For comparability with data from the current population survey, figures from the 1970 census have been adjusted to exclude inmates of institutions and members of the Armed Forces living in barracks and similar types of quarters.

[c] Based on total 1970 and 1960 census populations, including the categories not covered in the current population survey, except for Black, which is based on a 1-in-1,000 sample for 1960.

[d] Based on the method of exponential change.

[e] Refers to the 243 standard metropolitan statistical areas as defined in 1970 census publications.

[f] 1979 and 1970 data for the central cities refer to their 1970 corporate boundaries and exclude areas annexed since 1970; 1960 data refer to 1960 corporate boundaries.

[g] Persons of Spanish origin may be of any race.

Source: U.S. Department of Commerce, Bureau of the Census, *Population Profile of the United States: 1979*, Series P–20, No. 350 (Washington, D.C.: U.S. Government Printing Office, 1980), p. 26.

Table 8–2

Provisional Estimates of the Resident Population of States, 1979, and Components of Change, 1970

Region, division, and state	July 1, 1979	July 1, 1978	April 1, 1970 (census) [a]	Change, 1970 to 1979		Components of change			
				Number	Percent [b]	Births	Deaths	Net migration	
								Number	Percent [b]
United States	220,099	218,228	203,302	16,797	8.3	30,567	17,800	4,030	2.0
Northeast	49,002	49,092	49,061	— 59	— 0.1	6,186	4,423	— 1,821	— 3.7
North Central	58,406	58,258	56,590	1,815	3.2	8,318	4,906	— 1,596	— 2.8
South	71,550	70,642	62,813	8,737	13.9	10,303	5,710	4,144	6.6
West	41,142	40,236	34,838	6,304	18.1	5,761	2,760	3,303	9.5
Northeast									
New England	12,291	12,267	11,847	444	3.7	1,484	1,042	2	—
Middle Atlantic	36,711	36,825	37,213	— 502	— 1.4	4,702	3,381	— 1,823	— 4.9
North Central									
East North Central	41,287	41,221	40,263	1,025	2.5	5,948	3,418	— 1,506	— 3.7
West North Central	17,118	17,036	16,328	791	4.8	2,370	1,488	— 91	— 0.6
South									
South Atlantic	34,976	34,648	30,679	4,297	14.0	4,739	2,820	2,378	7.8
East South Central	14,105	13,960	12,808	1,297	10.1	2,124	1,202	375	2.9
West South Central	22,470	22,034	19,326	3,144	16.3	3,441	1,688	1,392	7.2
West									
Mountain	10,673	10,364	8,290	2,383	28.7	1,669	657	1,372	16.6
Pacific	30,469	29,871	26,548	3,920	14.8	4,092	2,103	1,931	7.3
New England									
Maine	1,097	1,092	994	103	10.4	149	98	52	5.2
New Hampshire	887	869	738	149	20.2	112	69	106	14.3
Vermont	492	487	445	49	10.9	66	40	22	5.0
Massachusetts	5,769	5,771	5,689	80	1.4	681	509	— 92	— 1.6
Rhode Island	929	932	950	— 20	— 2.1	114	85	— 49	— 5.2
Connecticut	3,115	3,116	3,032	83	2.7	361	242	— 37	— 1.2

Middle Atlantic									
New York	17,648	17,746	18,241	− 593	− 3.3	2,319	1,626	− 1,287	− 7.1
New Jersey	7,332	7,316	7,171	161	2.2	909	617	− 131	− 1.8
Pennsylvania	11,731	11,763	11,801	− 70	− 0.6	1,473	1,138	− 406	− 3.4
East North Central									
Ohio	10,731	10,732	10,657	73	0.7	1,546	908	− 565	− 5.3
Indiana	5,400	5,387	5,195	205	3.9	799	444	− 150	− 2.9
Illinois	11,229	11,238	11,110	119	1.1	1,647	986	− 542	− 4.9
Michigan	9,207	9,181	8,882	325	3.7	1,331	705	− 300	− 3.4
Wisconsin	4,720	4,683	4,418	302	6.8	625	375	52	1.2
West North Central									
Minnesota	4,060	4,024	3,806	254	6.7	546	309	16	0.4
Iowa	2,902	2,906	2,825	77	2.7	397	263	− 56	− 2.0
Missouri	4,867	4,847	4,678	190	4.1	670	465	− 16	− 0.3
North Dakota	657	653	618	39	6.3	98	51	− 8	− 1.3
South Dakota	689	690	666	23	3.4	107	61	− 23	− 3.5
Nebraska	1,574	1,569	1,485	89	6.0	226	137	—	—
Kansas	2,369	2,347	2,249	120	5.3	326	202	− 4	− 0.2
South Atlantic									
Delaware	582	584	548	34	6.2	81	45	− 2	− 0.4
Maryland	4,148	4,148	3,924	225	5.7	522	303	5	0.1
District of Columbia	656	671	757	− 101	− 13.4	102	71	− 131	− 17.4
Virginia	5,197	5,177	4,651	545	11.7	687	372	230	4.9
West Virginia	1,878	1,861	1,744	133	7.7	268	182	47	2.7
North Carolina	5,606	5,571	5,084	522	10.3	800	429	151	3.0
South Carolina	2,932	2,902	2,591	341	13.2	459	221	103	4.0
Georgia	5,117	5,075	4,588	529	11.5	795	393	128	2.8
Florida	8,860	8,661	6,791	2,068	30.5	1,024	804	1,848	27.2
East South Central									
Kentucky	3,527	3,490	3,221	306	9.5	523	308	91	2.8
Tennessee	4,380	4,333	3,926	454	11.6	612	360	202	5.1
Alabama	3,769	3,728	3,444	325	9.4	567	318	75	2.2
Mississippi	2,429	2,409	2,217	212	9.6	421	216	7	0.3

Table 8–2 (continued)

Provisional Estimates of the Resident Population of States, 1979, and Components of Change, 1970

Region, division, and state	July 1, 1979	July 1, 1978	April 1, 1970 (census) [a]	Change, 1970 to 1979		Components of change			
				Number	Percent [b]	Births	Deaths	Net migration	
								Number	Percent [b]
West South Central									
Arkansas	2,180	2,167	1,923	257	13.4	321	200	136	7.1
Louisiana	4,018	3,978	3,645	373	10.2	656	317	34	0.9
Oklahoma	2,892	2,843	2,559	332	13.0	406	250	177	6.9
Texas	13,380	13,047	11,199	2,182	19.5	2,058	921	1,045	9.3
Mountain									
Montana	786	780	694	92	13.2	115	62	38	5.4
Idaho	905	882	713	192	26.9	151	60	100	14.0
Wyoming	450	425	332	117	35.3	65	28	81	24.2
Colorado	2,772	2,706	2,210	563	25.5	379	166	350	15.8
New Mexico	1,241	1,215	1,017	224	22.1	204	74	94	9.3
Arizona	2,450	2,373	1,775	675	38.0	368	157	464	26.1
Utah	1,367	1,317	1,059	308	29.1	297	69	80	7.6
Nevada	702	666	489	213	43.6	89	41	165	33.8
Pacific									
Washington	3,926	3,793	3,413	513	15.0	497	279	295	8.6
Oregon	2,527	2,452	2,092	436	20.8	319	189	305	14.6
California	22,694	22,314	19,971	2,723	13.6	3,057	1,581	1,248	6.2
Alaska	406	411	303	104	34.3	71	14	47	15.6
Hawaii	915	902	770	145	18.8	149	40	36	4.6

[a] Includes officially recognized changes to census counts through October 1979.
[b] Percent of April 1, 1970, population.

Source: U.S. Department of Commerce, Bureau of the Census, *Population Profile of the United States: 1979*, Series P–20, No. 350 (Washington, D.C.: U.S. Government Printing Office, 1980), p. 28.

others are Colorado, North Carolina, Virginia, Georgia, Washington, Florida, Texas, and California.

Among the states losing population—all in the Northeast—New York was first (—593,000) and Pennsylvania second (—70,000). These states were part of the Frost Belt area of limited growth extending from Massachusetts to North Dakota. Notable exceptions were the three predominantly rural New England states, New Hampshire, Vermont, and Maine. Next to Florida, New Hampshire was the fastest growing state outside the West.

Metropolitan growth is still substantial in the West and Southwest, and rural growth is triple the national rate.[4] These phenomenal regional growth rates have contributed to the process of land degradation known as desertification. Desertification is becoming one of the nation's most serious environmental problems.

COASTAL AREAS AND FLOODPLAINS

Other areas where the population is growing, although not at the rates of the 1960s, are the coasts. The barrier islands, spits, and beaches—approximately 300 of them along the East and Gulf coasts—are among the least stable natural areas that people use. They are natural buffers against the ravages of ocean storms, and they protect inland wetlands, lagoons, and estuaries that support diverse coastal ecosystems and produce valuable fish and wildlife. Storms, tides, and the gradually rising level of the sea make barrier island settlement extremely hazardous. Nonetheless, barrier islands are very attractive to people. Since the late 1800s, many barrier islands, Atlantic City, and Ocean City, Maryland, for example, have become well-known resorts. Since World War II, development on barrier islands for recreation has been intense and rapid. Approximately 40 percent of the barrier island acreage has been acquired and managed by public agencies, local, state, and federal, primarily for this purpose.

A 1979 study reported that in 108 barrier island counties, the population had increased by more than 30 percent in the 1960s, well over twice the national growth rate.[5] Population grew 9.6 percent between 1970 and 1975, again twice the national growth for the period.

Between 1950 and 1974, the 1,605,000 acres of barrier islands, spits, and beaches in the United States were built upon, paved, and otherwise urbanized at twice the national rate for other kinds of lands. Approximately 138,000 acres were urbanized over the period, an average of 6,000 acres per year.[6]

Barrier island settlers contend with unalterable natural forces. Since 1900, 129 hurricanes on the Atlantic and Gulf coasts, including 53 considered major by the National Weather Service, have killed thousands of residents and caused billions of dollars of damage. Hurricanes Frederick and David in the fall of 1979 cost 10 lives and $2.6 billion in property destruction. More subtle but inexorable

changes in barrier island sea boundaries are occurring as well. In the Atlantic, the difficulties created by erosion and deposition of sand away from the islands are compounded by the long-term rise in sea level (1 foot since 1900). The U.S. Geological Survey reported that the beach front at Ocean City (a heavily built-up resort with an annual visitor population of more than 200,000) receded about 2 feet per year from 1938 to 1974. This change is typical of barrier islands along the Atlantic.[7]

Federal expenditures to protect existing development on barrier islands from storm erosion and other natural events and to provide disaster relief, beach enrichment, and flood insurance amount to hundreds of millions of dollars each year. In addition, the federal government spends tens of millions of dollars on barrier islands each year for water and sewer development, roads, and bridge construction. The issues raised by such federal expenditures are economic as well as environmental, and they are receiving increasing attention within the Congress and the Executive branch.[8]

Barrier islands are not the only flood-prone areas of development and population growth. Construction continues in the floodplains along rivers and coasts, despite their vulnerability to floods and frequently their value as agricultural land. Floodplains, including barrier islands, occupy 6–8 percent of the U.S. land area (140–180 million acres), and they contain some 6.4 million dwelling units in addition to substantial commercial and industrial development.[9] One indication of continued building in the floodplains is the rising cost of property losses caused by floods. A Presidential task force estimated annual flood losses at about $1 billion in 1966;[10] 10 years later the U.S. Water Resources Council (WRC) estimated that annual flood losses had more than doubled—$2.2 billion in 1967 dollars, $3.8 billion in 1979 dollars. If present settlement and property investment trends continue, WRC estimates 1985 losses of $5 billion (1979 dollars).[11]

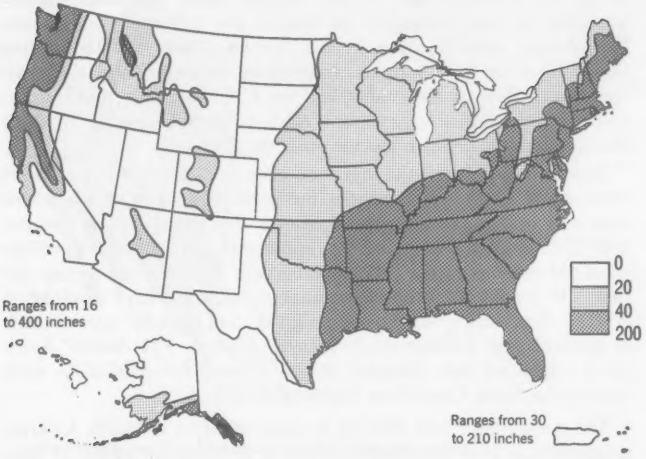
ARID LANDS AND DESERTIFICATION

Of the 1.9 billion acres of land in the lower 48 states, nearly half are in the arid zone.[12] Arid zones receive an average of less than 20 inches of precipitation per year (see Figure 8–1). Settlement of arid land began in earnest in the latter half of the 19th century. Early in the 20th century the federal government, having long encouraged the settlement, sale, and development of publicly owned lands in the West, began to support water projects that would attract settlers and make the desert bloom. In the mid-20th century, further migration resulted from the growth of retirement communities, tourism, and movement of industry to the Sun Belt.

In 1890, some 1.5 million people lived in the arid West. Today it contains more than 28 million people and more than 10 percent of

Figure 8-1

Average Annual Precipitation



Source: U.S. Water Resources Council, *The Nation's Water Resources: 1975-2000*, Vol. 1: *Summary* (Washington, D.C.: U.S. Government Printing Office, 1978), p. 16.

the major metropolitan areas. The population increased 27 percent in the 1960s and 29 percent in the 1970s. The area produced $8.7 billion in crops and $7.9 billion worth of livestock (23 million cattle and 7 million sheep) in 1977—18 percent of the nation's total agricultural output that year.[13]

The arid West is rich, it is productive, and it is critical to the national economy. But it is also undergoing rapid environmental change that seriously threatens its long-term productivity and habitability. The change is desertification—a serious degradation of the soil, the vegetation, and the ecological resilience of arid and semiarid lands. Desertification is characterized by the lowering of water tables, shortages of surface water, salinization of existing water supplies, and wind and water erosion. The principal reasons for desertification in the United States are overgrazing, the overdraft (mining) of ground water for agriculture, poorly managed irrigation and use of soils with poor drainage, choice of crops and agricultural practices that neglect soil conservation, industrial development, and rapid urban growth.[14] These conditions in the arid West are described below.

"Desertification" gained wide public notice during the severe drought and southward advance of the Sahara Desert in the Sahel (the southern rim of the Sahara) between 1968 and 1973. It was

the subject of an international conference convened by the United Nations in Nairobi in 1977.

Desertification in the Sahel and in western Rajasthan (India) causes great human misery—starvation or malnutrition for millions of people. Desertification in the United States has attracted less attention because its impact on human life is far less immediate. Nonetheless, desertification in the United States has far-ranging implications for food supplies, balance of payments, and the environment. Following the guidance of the UN conference, the Department of the Interior is heading a federal interagency-state effort to develop national policy recommendations.

Desertification is not the literal invasion of a desert into nondesert areas. Rather, the term includes the impoverishment of ecosystems *within* as well as outside natural deserts. For example, the Sonoran and Chihuahuan Deserts of the Southwest are perhaps a million years old as deserts; yet they have become more barren during the past 100 years. Their native animal populations have diminished greatly. Perennial grasses have declined, and invader species such as tamarisk and Russian thistle have multiplied. The deserts' floodplain vegetation has changed almost beyond recognition in such areas as the Santa Cruz River Valley of Arizona.

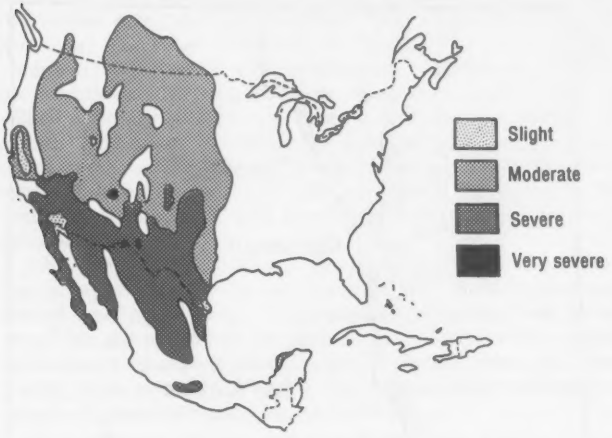
The overall land area affected by desertification in North America is substantial. It is estimated that 1.1 million square miles, 37 percent of the continent's arid lands, have undergone "severe" desertification marked by invasion of brush, devegetation by wind and water erosion, or high salinity build-ups that reduce crop yields more than 50 percent. Some 10,500 square miles of the continent have undergone "very severe" desertification in which large sand dunes and gullies appear or salt crusts have developed on nearly impermeable irrigated soils.[15] In contrast, Africa's "severe" desertification totals 4 million square miles, but its "very severe" desertification is less than that in North America—5,500 square miles.

Most of the very severe desertification in North America is in the United States, as shown in Figure 8–2. The northernmost area is on the Navajo Indian reservation. The other two areas bracket El Paso, one straddling the New Mexico-Mexico border and one straddling the Texas-New Mexico border. As many as 225 million acres *within* the United States, about 10 percent of the U.S. land mass,[16] appear to have undergone severe or very severe desertification. Almost twice that amount is threatened by severe desertification.

The United States has already suffered serious economic losses through desertification; future losses of far greater magnitude are possible. The costs incurred may be in the form of lower agricultural yields, increased costs of production and conservation programs, and the consequent ripple effects of these cost increases on local, state, and, eventually, national economic systems. Controlling the phenomenon of desertification may add significant short-term costs to

Figure 8-2

Status of Desertification in North America



Source: Harold Dregne, "Desertification of Arid Lands," *Economic Geography* 53 (4):325 (1977) (copyright © by Clark University).

arid land economies and may require the use of new resource management practices on private as well as public lands.

The causes of desertification are not well understood. The examples presented below illustrate some important causes and effects that are equally applicable to many other parts of the arid West.

THE RIO PUERCO BASIN AND OVERGRAZING

A prime example of the impacts of desertification is in the Rio Puerco Basin in northwestern New Mexico (see Figure 8–3). The 511,916-acre Rio Puerco Basin, one of the most eroded and overgrazed river basins in the arid West, was known less than a century ago as "the bread basket of New Mexico." Livestock grazing began there in the late 1700s. By the 1870s the Basin supported about 240,000 sheep and 9,000 cattle.[17] Along the alluvial floodplain of the river, numerous small farms flourished, using ditch irrigation.

But the era of rich productivity was brief. By the late 1880s, deterioration had begun. Water tables began to drop, arroyo was cut, and large quantities of sediment began to flow out of the area. The number of livestock grazed in the Basin peaked around 1910. Since then, herds and flocks have diminished steadily, except for a brief increase in sheep during the 1930s.

Figure 8-3

The Rio Puerco Basin

Source: Based on U.S. Geological Survey, Hydrologic Unit Map-1974, State of New Mexico.

Irrigated agriculture along the Rio Puerco fared even worse. What had been good, deep, fertile irrigated alluvial soil was largely replaced by deep fingering arroyos. One by one, formerly prosperous agricultural villages were abandoned during the first half of the century. By 1950 they were ghost towns. Between 1885 and 1962, an estimated 1.1–1.5 billion tons of soil washed from the Rio Puerco Basin into the Rio Grande.[18]

Whether this soil erosion in the Basin was caused more by natural climate changes or by overgrazing is a subject of scientific dispute. At the least, it appears that overgrazing accelerated the degradation of productive range and farmland. The process of erosion continues as the Rio Puerco contributes vast amounts of sediment to the Rio Grande.

Throughout the West, desertification has followed overgrazing.

The Bureau of Land Management (BLM), which manages 170 million acres of rangeland in the arid West alone, reported in 1975 that 50 percent of this range (81.5 million acres) was in "fair condition," 28 percent (45.6 million acres) in "poor condition," and 5 percent (8.2 million acres) in "bad condition." Only 17 percent (27.6 million acres) was either "excellent" or "good." The trend in range conditions was not much more encouraging. According to the BLM, the condition of 105.9 million acres (65 percent) was "static," 31 million acres (19 percent) was "improving," and 25.7 million (16 percent) "declining."[19] Overgrazing has long been recognized as a threat to the carrying capacity of arid lands everywhere. But newer causes of desertification have been increasingly significant in this century in the western United States. The most important causes involve water.

John Wesley Powell, understanding the scarcity of water as a limiting factor, warned in 1893 that the arid West could support only limited numbers of people if the soil and vegetation were to survive.[20] He did not foresee the scale of 20th century water resource development—pumping ground water, damming rivers, and transporting water over long distances—that would support a phenomenal growth of population and crop production.

Both technical changes and new government policies brought about the vast impoundments, transport, and use of water that characterize the arid West today. One technical development was the centrifugal pump which, when coupled with an internal combustion engine or an electric motor, can suck water from underground in far greater volume, at greater speed, and from much greater depths than can the windmill. About 55 percent of the water used for irrigation in the arid West comes from underground sources.[21] About 80 percent of the municipal drinking water systems are supplied by ground water. Several of the fast-growing metropolitan areas rely heavily on ground water, including Fresno, Tucson, Albuquerque, and Lubbock.

Damming rivers and transporting water over considerable distances require vast sums. In Powell's time and for many years thereafter, the arid West lacked capital. Ultimately, it was federal dollars that financed the lion's share of the region's water projects. Currently funded projects include the Central Arizona Project, $1.5 billion, which is under construction, and the Central Valley Project of California, $3.5 billion, which is almost completed.[22] "One out of every five persons in the [arid] western states is served by a water supply system that imports [water] from a source 100 or more miles away. In total tonnage, the volume [of water moved] exceeds the freight carried by all the region's railroads, trucks, and barges combined."[23]

Despite these huge water projects, the region's basic deficiency—its scarcity of water—remains. In fact, in important respects the projects have led to greater development and new kinds of environmental stress on land resources. And they have not arrested the process of desertification.

THE SAN JOAQUIN BASIN AND MULTIPLE CAUSES

California's San Joaquin Basin is one of a few areas that has suffered from all the major forces of desertification—poor drainage of irrigated land, overgrazing, cultivation of highly erodible soils, overdraft of ground water, and damage from off-road vehicles.

The San Joaquin Basin comprises the southern half of the great Central Valley of California, lying between the coastal mountain ranges and the Sierra Nevadas (see Figure 8–4). It encompasses 18.2 million acres, with the flat Valley floor and foothills covering about 10 million acres.[24] Annual precipitation in the north averages about 14 inches per year and declines to about 5 inches in the southernmost Tulare subbasin. Nonetheless, when irrigated, this is one of the most productive agricultural areas of the world.[25]

The eight San Joaquin counties produced $4.76 billion worth of farm products in 1977, more than any state except Iowa, Texas, and Illinois. The San Joaquin produces cotton, grapes, tomatoes, alfalfa, sugar beets, walnuts, almonds, oranges, apricots, and other tree crops. It also has a sizable livestock industry.[26]

About 100 years ago, cattle and sheep grazing began to transform the Valley's ecosystem. Between the coastal ranges and the Valley trough were mostly grasslands dotted with oak trees, although desert shrubs grew in portions of the Valley. There were large marshes and shallow lakes. Today the extensive wetlands have virtually disappeared, most of the wildlife is gone, and the native perennial grasses on the Valley floor and in the foothills have largely vanished. Native grasses were destroyed by the combination of cattle and sheep overgrazing and the introduction of European plant species such as filaree. In addition, great expanses of grassland have been plowed for agriculture or converted to urban use. Today major portions of the Valley are an irrigated crop-producing factory.

Poor Drainage of Irrigated Land

Of the Basin's 4.8 million acres of cultivated cropland, 4.6 million are irrigated. Twenty percent of the water is from outside the Basin, most of it from northern California,[27] from reservoirs and aqueducts built by the federal and state governments. The cost to the irrigator ranges from $12 to $35 per acre-foot (an acre-foot of water would cover 1 acre of land with 1 foot of water).

Today about 400,000 acres of irrigated farmland in the San Joaquin are affected by high brackish water tables. Water remains "perched" near the surface because of impervious substrata or high water tables. As plants and evaporation remove relatively pure water, the water which remains becomes increasingly saline. Losses in crop yields on this poorly drained land are 10 percent, approximately $31.2 million, annually. Unless a means is found to stop the progressive waterlogging and salinization now taking place, the amount of poorly drained land will increase to 700,000 acres by the year 2000,

Figure 8-4

The San Joaquin Basin

Source: Based on U.S. Geological Survey, Hydrologic Unit Map–1974, State of California.

and the loss in annual crop yield will reach $321.3 million. Some 1.1 million of the total 18.2 million acres of San Joaquin farmland could become unproductive in 100 years.

It is probable that some damaged land will have to be taken out of agricultural production entirely, although how much is impossible to judge from current data. Land that was once desert—if it is not so severely damaged that it has become a salt flat—will eventually revert to desert, although the process will take several hundred years. Meanwhile, the lack of vegetation and desert pavement (a thin layer of rocks of various sizes) will make this "orphan" land vulnerable to wind erosion, especially during drought. On land taken out of farm production that was once native perennial grassland, vegetation will return more swiftly but in a debased form, dominated by invader weed species such as Russian thistle and filaree. During times of drought, this land too will be vulnerable to wind erosion, and, if it slopes, it will be vulnerable to water erosion.

The solution to the San Joaquin salinization problem is to install subsurface drainage systems for collection and disposal of the saline ground water. But draining the saline water would cause environmental and economic problems and would be costly at best. The U.S. Water and Power Resources Service (formerly the Bureau of Reclamation) and two California water agencies have proposed a 290-mile master drain through the length of the valley, with the federal government paying most of the cost—$258 million (1979 dollars)—and the state providing the balance—$89 million.[28] These figures do not include installation of drainage systems on individual farms to tie into the master drain. Nor does the plan solve the problem of depositing the salty water elsewhere without causing other environmental damages. As proposed, the master drain would empty saline water into the Suisun Bay, northeast of Oakland, directly into the 1,150-square-mile delta, California's last great wetland system where the Sacramento and San Joaquin Rivers converge—or it would be pumped up into a salt flat to the south.[29] Other structural systems have been proposed, but all pose economic and environmental difficulties.

Suggested nonstructural alternatives include more efficient use of irrigation water, which might reduce on-farm use in the northern San Joaquin Basin about 15 percent and southern on-farm use nearly 20 percent.[30] Another possibility is to plant salt-tolerant crops and, to a limited degree, to reduce plantings. Some of these remedies, which would decrease farm income in the short term, are not likely to be implemented without special incentives. In addition, these remedies would have to be combined with widespread use of small-scale structural drainage and disposal systems.

Another solution would be to convert all problem drainage areas to well-managed grazing land. However, existing market forces, i.e., the price of crops that can be grown here versus livestock prices, militate against the proposal. Farmers in the San Joaquin prefer to import more water from northern California, plow up more ground, grow more crops, and pump more water from the aquifers.

Ground Water Depletion

About 40 percent of the irrigation water used in the San Joaquin comes from within the Basin, 10 percent from streams and 30 percent from underground aquifers. About 1.5 million acre-feet more water is pumped from these aquifers each year than is replenished naturally. This overdraft accounts for 12.5 percent of the San Joaquin's average annual water supply.[31] Thus part of the San Joaquin's agricultural prosperity rests on the shaky foundation of ground water overdraft.

Whether the depletion of ground water resources will also lead to loss of prime farmland in the San Joaquin ultimately depends on the efficient use of irrigation water, the ability of the San Joaquin to

import still more water from other basins, and, primarily, on energy costs.

Irrigated agriculture in California is energy intensive. In 1972, approximately 7 billion kilowatt-hours of energy were used to pump irrigation water—more energy than the combined gasoline and diesel energy used for plowing, planting, and harvesting. In the southern San Joaquin, 50 percent of the total energy used in irrigated agriculture was for pumping water; in the north, it was 18 percent.[32]

Dropping ground water levels and rising energy prices will surely make the pumping of ground water an increasingly significant cost item in San Joaquin agriculture. At some point, the cost will become prohibitive, as it has already in parts of the Pecos River Valley in southwestern Texas.

Ground water mining also contributes to desertification. The major physical effect of ground water overdraft in the San Joaquin has been land subsidence. When water is removed from a stratified underground waterbearing geological formation consisting of fine-grained unconsolidated sediments with clay interbeds, the structure may be compressed. In the San Joaquin, about 5,200 square miles of land had subsided by 1972; about 4,200 square miles have subsided more than 1 foot. The greatest subsidence occurred in the western San Joaquin where some areas sank 29 feet. In some of these areas where wells were once quite shallow, most wells are now 2,000 or more feet deep, with a few as deep as 3,500 feet.[33]

The major immediate cost of subsidence is damage to irrigation and drainage facilities, particularly canals and underground pipes. For example, from 1975 to 1976, Interior spent about $3.7 million to rehabilitate federal irrigation projects damaged by subsidence.[34] On-farm costs can also be high. In some places in the San Joaquin, tilting of the land surface caused by subsidence has changed the entire flow pattern on farms and has required realignment of entire irrigation systems.[35]

Another consequence of ground water overdraft can be more serious and of longer duration when an aquifer system is compressed because of the withdrawal of water—the amount of pore space that enables the aquifer system to store water shrinks. Thus, aquifer systems which have experienced permanent subsidence lose some of their valuable water-storing capacity.

Overgrazing

In terms of acreage affected, overgrazing is still a serious land degradation force in the San Joaquin, second only to irrigation. An interagency basin study concluded: "Of the four million acres of private rangeland [in the basin], 3.2 million acres, or 80 percent, has problems."[37] Of the public rangeland managed by the Forest Service, 20 percent, 102,000 acres, were found to have problems.[38] The BLM rangeland in the Basin—about 400,000 acres—was not ana-

lyzed by this study, but it is thought to be in roughly the same condition as the private land.[39]

The interagency study found that 338,000 acres were so badly overgrazed that they could not revegetate; on some of this land, woody and noxious plants were replacing forage vegetation.[40] In short, this land is undergoing desertification.

Land abuse of this sort also accelerates soil erosion. Some 2.2 million acres of foothills and mountains in the San Joaquin Basin, most of them rangeland, are undergoing serious water erosion. Erosion causes an estimated $1.2 million annual loss in forage in the San Joaquin.[41] The sediment that it deposits adds to the cost.

Overgrazing leaves the land susceptible to the erosive force of the wind as well. This fact was demonstrated in December 1977 in the southern San Joaquin in the Bakersfield area. In 24 hours, the wind moved more than 25 million tons of soil in a 373-square-mile rangeland area. Soil losses in some foothills reached 23.7 inches. As the storm moved down onto the valley floor, it scoured the recently plowed fields, and comparable amounts of soil were displaced. A gigantic cloud of dust, i.e., soil, extended northward to at least the far end of the Sacramento Valley, some 360 miles away.[42] The wind removed 167 tons of soil *per acre* from the affected rangeland, representing a financial loss in nutrients estimated to exceed $20 million.[43]

A U.S. Geological Survey (USGS) study of the windstorm's impact noted that the land "was particularly vulnerable to wind erosion because the vegetative cover had deteriorated seriously under the

Severe salinization threatens the agriculturally prosperous San Joaquin Valley in central California (U.S. Bureau of Land Management).

combined stresses of drought and grazing."[44] A 3-month period of unusually heavy rainfall after the windstorm caused further severe damage to the southern San Joaquin. The USGS observed that "slopes laid bare by the windstorm" contributed greatly to the severity of the flooding, increasing water and mud runoff.

Off-Road Vehicles

The USGS study cites recreation, especially by off-road vehicles, as another major cause of rangeland deterioration. Some 521,000 acres of San Joaquin rangeland have suffered reduced productivity from intensive recreational use of the land: "Off-road vehicles and other recreational pursuits destroy vegetative cover and accelerate erosion."[45]

Urbanization

Soil experts are also concerned about the effects of urban sprawl on the San Joaquin. When bulldozers move into the foothills, they strip away the natural vegetation and expose vulnerable soils to sheet and gully erosion. In its study of the great windstorm of 1977, the USGS reported that construction sites, off-road vehicle areas, and roadcuts and shoulders in the Bakersfield area were an important source of the sand which aggravated the destructive force of the wind: "Soil erosion resulted principally from scour by wind-driven sand and spread downwind of the unprotected sand sources."[46]

The San Joaquin has three rapidly growing urban areas: Fresno, Bakersfield, and Modesto. Urbanization is projected to take over approximately 407,100 acres of prime farmland in the San Joaquin between 1972 and the year 2000.[47]

FARMING IN RANCH COUNTRY

The desertification forces evident in the San Joaquin Basin have been at work throughout the arid West. Arid lands that have become highly productive for farm crops have suffered severe soil erosion and the loss of ground water resources on which profitable crop production depends. These adverse effects have been encouraged both by market factors and—often inadvertently—by federal policy.

Soil conservation practices encouraged or paid for by the federal government since the 1930s have not arrested the widespread soil erosion of productive cropland in the arid West. Erosion in Gaines County, Texas, illustrates the problem. Forty years ago Gaines County was rangeland. Now it is the ninth most productive county in cash crop output in Texas, the nation's fourth most productive agricultural state. In the drought year of 1977, Gaines County farmers produced $73 million worth of crops, mostly cotton. Yet a 1976 General Accounting Office (GAO) study found that 31 of 39 Gaines County farms studied were suffering soil losses of 40 tons or more

per acre per year compared to a national average of less than 5 tons.[48]

In the productive Portales area of New Mexico, the same study found that 19 of 28 farms sampled were losing soil at rates of 10–40 tons per acre per year.[49] One severe windstorm in February 1977 removed some 40 tons of soil per acre in just 24 hours.[50] To the north, in Kiowa and Crawley Counties, Colorado, the same storm caused losses of up to 150 tons per acre.[51]

Contributing to these serious losses was the fact that farmers had plowed up and planted highly erodible marginal lands to take advantage of the rapidly rising prices resulting from the massive 1972 wheat sale to the USSR.

Termination of "soil bank" funds of the Conservation Agricultural Program in 1966—under which farmers were paid to remove land from cultivation—also contributed to cultivation of marginal land. For 10 years in the 1960s and early 1970s, some 241,000 acres in the Portales Valley were removed from crop production. But by 1975, 75 percent of this land, much of it marginal, was again being farmed. In Kiowa County, Colorado, 150,000 acres of what the Department of Agriculture calls Class VI land, land that is generally unsuited to cultivation and is best restricted to pasture, range, woodland, or wildlife habitat, is now under cultivation. Not surprisingly, these acres are eroding at a rate well above the national average—about 20 tons per acre per year.[52]

Federal disaster relief programs of the Department of Agriculture compensate farmers for damage to crops (wheat, feed grains, cotton) by wind erosion or drought. In Gaines County, where much Class VI land is under cultivation, federal disaster relief funds soared from $2.3 million to $10 million between 1977 and 1978. Here and elsewhere in the Texas high plains, federal crop disaster payments have become an integral part of the agricultural economy. An unexpected result is that incentives to retire highly erodible marginal land from production are reduced.[53]

The structure and availability of relief payments have also discouraged strip cropping (planting grass between strips of row crops), crop rotation, and the planting of permanent cover on highly erodible land. Perverse effects arise from basing federal payments partly on the total crop acreage planted. Payments are calculated by multiplying established yields per acre by 60–75 percent of the planted acreage (depending on the crop), a formula that encourages farmers to plant the maximum acreage. If production is less than the total, the federal government pays the difference. Unless estimates of established yields per acre—set by the local Agricultural Stabilization and Conservation Service—reflect the limitations of marginal lands, farmers have an added inducement to produce on lands otherwise best left to grassland.

The Federal Great Plains Conservation Program[54] has not yet reached its intended goal, to protect national soil resources by help-

ing farmers to convert erosion-prone cropland into grassland on a cost-share basis. Established in 1966, this Soil Conservation Service (SCS) Program has helped farmers establish vegetative cover on some 2.4 million acres of the Great Plains and to reseed 1.9 million acres of rangeland. The SCS has estimated that it would bring some 8.3 million acres (of a desired total of 16 million acres) under the Program by 1981. Because the Program was scheduled to terminate in early 1981, President Carter signed a bill authorizing a 10-year extension.[55] At the same time, the Department of Agriculture is evaluating the efficacy of the Great Plains Conservation Program.[56] The GAO has reported that one-fourth of the farmers in the program have recultivated the converted land after their 3- to 10-year government agreements expired and that many more plan to do so.[57] Further, less than one-third of Program funds have been spent to establish permanent vegetative cover on highly erodible cropland or to reseed rangeland, and much of the remaining two-thirds of the funds has been devoted to livestock improvement efforts. Many farmers have found that it is not profitable to convert cropland to range under the Program.

THE INCREASING SCARCITY OF WATER

Inadequate water supply from surface sources or aquifers has become an increasing problem for agricultural, urban, and industrial uses in the arid West. As noted in the Council's 1979 Annual Report,[58] surface water shortages are particularly acute in the Colorado River Basin despite substantial federal investment in dams and diversions. Tucson, the largest U.S. city to depend entirely on ground water, has purchased and retired from use about 12,000 acres of farmland to augment its water supply by gaining control of irrigation water rights. City officials anticipate the need to purchase another 36,000 acres of land by 1985.[59] Given these trends, prospects for continued irrigated agriculture around Tucson, nearly 46,000 acres in 1977, are poor. The number of fields no longer irrigable will increase. It is likely that these lands, instead of being returned to their native vegetative cover, will be surrendered to weed species and ravages of wind and water erosion.

Urbanization elsewhere in the arid West is causing similar abandonment of cropland. Some 50,000 acres of formerly irrigated cropland have been abandoned to serve the water needs of the growing Pueblo and Colorado Springs metropolitan area. Dryland farming is not practical, and conversion to perennial grassland requires time and money.

Overdraft of ground water is just as serious a problem for agricultural areas as it is for urban settlements.

The High Plains region, for example, is underlain by the Ogallala aquifer, which suports agriculture on more than 11 million acres. But water overdraft is severe and it is increasing. The water level

under Gaines County, Texas, has dropped 12.8 feet in the past 10 years.[60] Aquifer depletion and rising energy prices in Gaines County have caused pumping costs to rise about fortyfold since 1970.[61] In the Pecos River Valley of Texas, 100,000 acres of cropland have been abandoned because of the increased price of natural gas used for pumping ground water. Parts of Kansas and Nebraska have experienced similar problems, and difficulties are anticipated for lands now being heavily irrigated. A drop of 6.4 feet in the water table occurred between 1974 and 1978.[62] The Ogallala and its future are being studied by the U.S. Geological Survey, the Water and Power Resources Service, and the Economic Development Administration in the Department of Commerce.

Total federal expenditures and subsidies in the arid West have not been tallied. Like federal support for the development in hazardous coastal floodplains and on barrier islands, federal investments and subsidies for arid land development may bring important benefits to large numbers of people, at least in the short term. But long-term costs to the general public may be far greater than the benefits.

In the arid West, as in the coastal zone, federal expenditures have encouraged patterns of human settlement and resource development that are not environmentally and economically sustainable. It is possible that the High Plains will seek federal help to import surface water from the Mississippi when ground water supplies become uneconomical. Further requests for federal funds may be expected to rescue the expanding metropolitan areas of the arid zone when their existing surface and ground water supplies approach exhaustion. In an era of tight federal budgets, inflation, and rising energy prices, public debate about the costs and benefits of federal aid and support for potentially unsustainable settlement patterns and use of land—whether in arid or coastal areas—will undoubtedly increase.

CONSERVING THE NATION'S AGRICULTURAL LANDS

Protection of the soil and biological resources of the arid and semi-arid parts of the United States is just one aspect of a broader national imperative—to preserve our uniquely valuable capacity to grow food for domestic use and for export. Preserving the quality of the nation's soil resources through soil conservation and maintaining the amount of the nation's prime farmland are fundamental resource management goals for the nation. Prime farmland is land with extremely desirable soil, moisture, climate, drainage, slope, and other characteristics for growing crops. Because of these attributes, it is the most efficient, energy-conserving, and environmentally stable land for food production.[63]

The most reliable data available suggest that the conversion of rural land to urban, water resource, transportation, and other non-

farm uses has caused annual losses of approximately 3 million acres of agricultural land between 1967 and 1977 out of a total of 1.36 billion acres of nonfederal rural land.[64] This figure includes about 1 million acres lost from existing cropland each year. The total annual loss to urban and built-up uses from 1967 to 1977 was "nearly three times the rate in the 1958–1967 period." [65]

The gradual and irreversible conversion of agricultural land to nonfarm uses has increased public awareness of the value of the nation's agricultural resources. International demand for U.S. farm products has also added to concern about the protection of agricultural land. U.S. excess productive capacity now accounts for some $31 billion in export trade each year in basic farm commodities.[66] All projections indicate that the volume and dollar value of agricultural exports should continue to rise.

Increased food prices following the 1980 summer drought indicate the sensitivity of the agricultural economy to unfavorable weather conditions. The Department of Agriculture projections indicate that the physical limits of productive capacity may be reached by the year 2030 or even well before under a number of plausible conditions.[67] Long before physical limits of productive capacity are reached, however, the economic or environmental costs of producing food may well become dominant factors in determining feasible production levels. As food, recreation, energy, and other demands compete for agricultural resources, consumer food prices can be contained and the necessary conservation and environmental goals can be maintained only if lands remain available for conversion to agriculture when needed.

To assess the implications of agricultural land conversion and to examine sometimes conflicting policies affecting agricultural land, CEQ and the Department of Agriculture initiated the National Agricultural Lands Study (NALS) in 1979. The primary goal of the project is to clarify and explore the nature of agricultural land conversion, to determine what is known and what will remain uncertain about future pressure on land resources, and to analyze ways in which local, state, and federal governments can respond to the critical agricultural land issues.

Pressures from urban and suburban expansion, transportation systems of all kinds, and rural development such as shopping centers, housing, industrial parks, and other building projects all contribute to loss of agricultural land. These rural changes are illusive and are difficult to measure. That they are pervasive, however, is evident from a 1979 survey by the National Association of Conservation Districts.[68] Conservation Districts (there are about 3,000 of them) are local units of government authorized under state law to institute soil conservation practices and to cooperate with and receive funds from federal and state agricultural agencies. According to the survey, 41 percent of District officials believed that the loss of agricultural land to urbanization was a serious problem.

Fairfax County, Virginia. Competition for land use continues between farming and suburban expansion (Susan Portney).

In the Corn Belt, only 5 percent of the Districts reported that farmland loss was *not* a problem, the lowest percentage so reporting of all regions in the country.[69]

Not all the pressures on farmland have been caused by net shifts of national population to rural areas. Population distribution changes within counties—the out-migration of the traditional population and the in-migration of others as a result of opportunities for non-agricultural employment, possibly in conjunction with the trend toward increasing numbers of (smaller) households[70]—have also caused potentially significant farmland losses. New housing developments in rural areas almost always consume previously open land, often cultivated farmland. Older rural settlements and the roads serving traditional homesteads rarely return to farmland when abandoned.

A recent CEQ study of the land use effects of growth in five rural areas revealed the fact that net population increases are not necessarily the key factor in land use change.[71] Several counties in the agricultural region in Illinois and Wisconsin, some 100 miles from Milwaukee and Chicago, exemplify this point. Green County, Wisconsin (population 29,400), which grew about 5 percent between 1970 and 1977, lost 10,000 of its 214,000 acres of harvested farmland in this period. Building permits in unincorporated areas of the County and construction of new highways tripled.

By contrast, neighboring Jo Davis County, in Illinois (population 22,600), grew only 0.8 percent at the same time. At this rate it would not regain its 1870 population until 1990. Yet between 1969 and 1974, Jo Davis County lost more than 20,000 acres of farmland

to other uses, primarily to new second home and recreational development.

Adjacent Stephenson County, Illinois (population 46,700), experienced a decline in population of 7.1 percent between 1970 and 1977. Yet the size of the work force rose 12.5 percent as new manufacturing and insurance companies came to the County. New housing was needed, and developments sprang up in scattered locations, usually followed by new shopping centers and other commercial developments. As a result, some 1,000 acres of prime farmland were converted to non-agricultural uses each year.

Both farmers and county planners recognize that without well-conceived rural development strategies, the direct loss of farmland can be aggravated by significant indirect losses. On the average, for each acre lost directly to urban and rural buildup and to transportation uses, at least 1 more acre is isolated by leapfrog development and is lost to agricultural use.[72] In addition, the interspersion of new housing on land adjacent to farms—even on poor soils—creates potential conflicts between farmers and new residents concerned about the odors, use of fertilizers, noise, and other factors that they associate with agriculture. Sometimes new residents bring pressure to discourage agriculture, which has somehow become incompatible with the rural life that they are seeking.

In-migration also leads to substantial conversion of farmland. Consider the Sun Belt counties in New Mexico. Taos County (population 19,900) and Santa Fe County (population 65,000) are historic Spanish communities whose economy has depended heavily on irrigated agriculture in fertile river valleys. Between 1970 and 1975, their populations grew by 10.6 percent and 14.0 percent, respectively.[73]

These net in-migration figures mask a substantial turnover of population. Santa Fe's population increased 1,600 between 1974 and 1976, but 10,314 moved in and 8,700 moved out. In Taos, the number of immigrants—2,726—was 14 times the average of 200 *net* migrants for the 2 years. Further, new residents preferred to live in the verdant, irrigated agricultural valleys, which constitute only 1.3 percent of the land area of Santa Fe County and 2.8 percent of Taos, rather than on the dry hillsides. Santa Fe lost 14 percent of its agricultural land to homesites in the 1960s. If such trends continue, New Mexico could lose almost one-half its prime agricultural land to housing and related development by the end of the century.[74]

Whether the rural growth trend will continue as energy costs escalate rapidly is not known. The sharp rise in gasoline costs in the mid-1970s did not, in fact, noticeably affect rural growth. A recent Department of Agriculture study of commuting patterns in rural areas helps explain the reasons and suggests that rural growth may continue irrespective of gasoline prices.[75]

The study found that only 9 percent of all employed household heads and an estimated 7 percent of all employed people in nonmetropolitan areas commute to jobs in metropolitan areas, despite the fact that more than one-half the total rural population lives in counties that adjoin metropolitan areas. Further, among the recent migrants from cities to rural areas, only 17 percent commuted to work in the cities. The vast majority of the employed newcomers found new jobs in the rural communities. Rural areas are not merely bedroom communities but are indeed creating their own economic base.

The study also found that 21 percent of nonmetropolitan heads of households who worked away from home shared their automobile transportation with at least one other person. In urban areas, where carpooling pressures and opportunities might appear greater, the figure is 17 percent.

Employees in nonmetropolitan areas were found to travel shorter median distances to work than urban workers, even when calculations excluded people working at home. Overall, the median commuting distance was about 40 percent shorter for rural than for urban household heads.

There does not appear to be "any disproportionate reliance of non-metro people on automotive commuting, driving alone, or on long average trip lengths in comparison with the metro population." [76] The study raises the possibility that increased gasoline prices may affect the nonmetropolitan counties which are growing because they are within long commuting distance of urban employment; if so, rural growth might be constrained to the areas around employment centers in smaller towns. However, because new employment centers are often located away from established population centers, in suburban fringe and rural areas, the scattered pattern of development that has characterized rural settlement since 1970 may continue.

LAND USE AND URBAN DEVELOPMENT POLICIES

When land is permanently converted to housing, commerce, or industry and to public services, including highways, airports, water and sewer facilities, and other infrastructure, the environmental impacts are considerable. The federal government provides a variety of subsidies to virtually all these developments. Often, by providing needed public services, the government inadvertently creates undesirable settlement patterns and environmental effects. A recent report prepared by the Department of Housing and Urban Development describes some of the most significant effects of federal subsidies in urban areas.[77] Some of its conclusions are summarized below.

TAX POLICY

The tax system affects land development (and land conservation) more broadly than do other federal policies because it applies to all land transactions and affects all land values. For example, the investment tax credit may favor new development by providing incentives to invest capital in new commercial and industrial ventures, which are likely to locate in expanding areas of the country. The investment tax credit costs the public about $10 billion per year.[78] If it favors expanding communities, which are generally located in the South and West, it may unintentionally exacerbate economic losses in older cities in the Midwest and the Northeast.

Significant land use effects can also result from allowing the value of commercial or industrial property to be depreciated on an accelerated schedule that is intended to encourage investment in new plants and equipment. Additional investment in existing facilities is therefore discouraged. Accelerated depreciation costs the public about $400 million per year in forgone income.[79] Like the investment tax credit, accelerated depreciation can favor growing businesses and communities at the expense of older cities.

Tax-exempt bonds are used to raise capital for all sorts of infrastructure, including water supply projects, transportation, and industrial sites. Tax-exempt bonds cost billions in revenue losses each year.[80] Bond issues are not subject to individual scrutiny. If they meet basic Internal Revenue Service criteria, bonds can be issued without further federal or public oversight despite the substantial public subsidy involved. Sometimes the infrastructure financed by these bonds runs counter to federal policies intended to discourage development in floodplains, to encourage investment in cities rather than suburbs, or to encourage water conservation, energy conservation, or the protection of valuable natural ecosystems.

TRANSPORTATION POLICY

The nation's waterways, railroads, highways, transit systems, and airports strongly and directly affect settlement patterns and land use. Unlike the tax system, which has pervasive effects, transportation facilities tend to change the attractiveness and economic value of particular areas by providing or inhibiting access for people and goods. An issue now gaining increased attention is the cost of maintaining sewer, waterway, and other transportation investments which have frequently directed the nation's settlement patterns. Particularly visible is the problem of maintaining the vast highway system built in the last 30 years.

Federal support for transportation, primarily highways, is about $12 billion for construction and $5 billion in related administrative support each year. Federal grants have been available largely for new construction; state and local government agencies that plan

and build the projects are usually responsible for their maintenance. But federal construction grants have often encouraged state or local officials to build without planning for maintenance. As a result, the extensive but deteriorating national highway system is in need of further huge investments merely to keep it usable. Some states have highways that are almost literally falling apart.[81] Because of the division of financial responsibility, the older cities with highways and other infrastructure requiring costly maintenance may have to use their local taxes while newer cities can obtain large federal grants to build new systems that will attract new people and businesses.

One solution to the problems caused by building roads and other infrastructure without regard to the costs of maintenance would be to require applicants for federal funds to include plans for the long-term life-cycle costs of proposed projects. Cities or states might designate taxes or new user fees as potential sources of maintenance revenue. Residents could then anticipate costs before approving new expenditures, development plans, or bond issues. If federal programs fail to require applicants to plan their own funding of long-term maintenance, the result may be extremely high and increasing costs to all taxpayers.

REFERENCES

1. Comptroller General of the United States, *The Taking of Prime Farmland—What Should Be Done about It?* draft (U.S. General Accounting Office, 1979), p. i.
2. Council on Environmental Quality, *Environmental Quality—1979: The Tenth Annual Report of the Council on Environmental Quality* (Washington, D.C.: U.S. Government Printing Office, 1979), pp. 498–512.
3. U.S. Bureau of the Census, *Current Population Reports,* Series P–25, No. 876 (Washington, D.C.: U.S. Government Printing Office, 1980), p. 6.
4. Council on Environmental Quality, *supra* note 2, at 481.
5. U.S. Department of the Interior, Heritage Conservation and Recreation Service, in conjunction with the National Park Service, Fish and Wildlife Service, Office of Coastal Zone Management, Council on Environmental Quality, "Alternative Policies for Protecting Barrier Islands Along the Atlantic and Gulf Coasts of the United States and Draft Environmental Statement" (Washington, D.C., 1979), p. 125.
6. *Ibid.*
7. Robert Dolan, Harry Lins, and John Stewart, *Geological Analysis of Fenwick Island, Maryland, a Middle Atlantic Coast Barrier Island,* Geological Survey Professional Paper 1177–A (Washington, D.C.: U.S. Government Printing Office, 1980), p. 16.
8. Hearings before the House Committee on Interior and Insular Affairs concerning H.R. 5981, March 24, 1980, and the Senate Committee on Energy and Natural Resources, June 12, 1980.
9. Rutherford Platt, "Options To Improve Federal Nonstructural Response to Floods," prepared for the President's Committee on Water Policy (U.S. Water Resources Council, 1979), p. 1.
10. *Ibid.*

11. *Ibid.*
12. U.S. Water Resources Council, *The Nation's Water Resources 1975–2000,* Vol. 1: *Summary* (Washington, D.C.: U.S. Government Printing Office, 1978), p. 16.
13. Information provided by the U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service.
14. David Sheridan, *Desertification of the United States* (Washington, D.C.: U.S. Government Printing Office, in press).
15. Harold E. Dregne, "Desertification of Arid Lands," *Economic Geography* 33(4):329 (1977).
16. Harold E. Dregne, Texas Tech University, Lubbock, interview with David Sheridan, May 7, 1979.
17. U.S. Bureau of Land Management, *Final Environmental Impact Statement—The Proposed Rio Puerco Livestock Grazing Management Program,* 771–869 (Washington, D.C.: U.S. Government Printing Office, 1978), pp. II–71.
18. Cynthia Irwin-Williams, "Effects of Environmental Stress on Rural Populations," grant application to the U.S. Public Health Service (Portales, Eastern New Mexico University, 1977), pp. 25, 39–40; Edward J. Dortignae. "Rio Puerco: Abused Basin," in Carla Hodge and Peter C. Duisberg, eds., *Aridity and Man* (Washington, D.C.: American Association for the Advancement of Science, 1963), pp. 512–14.
19. U.S. Bureau of Land Management, *Range Condition Report,* prepared for the Senate Committee on Appropriations, 27–355/325 (Washington, D.C.: U.S. Government Printing Office, 1975), pp. I–12–13.
20. Wallace Stegner, *Beyond the Hundredth Meridian* (Boston, Mass.: Houghton Mifflin Co., 1954), pp. 230–31.
21. Comptroller General of the United States, *Ground Water: An Overview,* CED 77–69 (Washington, D.C.: U.S. Government Printing Office, 1977), pp. 1–4.
22. *Id.* pp. 5–7.
23. Frank Quinn, "Water Transfers: Must the American West Be Won Again?" *Geographical Review* 58(1):115 (1968).
24. U.S. Department of Agriculture (River Basin Planning Staff, Soil Conservation Service, Forest Service, and Economic Research Service), in cooperation with the California Department of Water Resources, *San Joaquin Valley Basin Study* (Washington, D.C., 1977), pp. 37–44.
25. U.S. Bureau of Reclamation, California Department of Water Resources, and California State Water Resources Control Board, *Agricultural Drainage and Salt Management in the San Joaquin Valley* (Fresno: San Joaquin Valley Interagency Drainage Program, 1979), pp. 2.1–2.3.
26. *Id.* p. 2.1; U.S. Department of Agriculture, Economics, Statistics, and Cooperative Services, Washington, D.C., 1979.
27. U.S. Bureau of Reclamation et al., *supra* note 25, at 2.3, 4.1–4.2.
28. *Id.* pp. 11.1–11.11.
29. *Id.* 2.1–12.2.
30. H.E. Horton, U.S. Bureau of Reclamation; Dave DeBruyn, U.S. Bureau of Reclamation; Robert Hagen, Department of Land, Air and Water Resources, University of California, Davis; Bill Pruitt, Department of Land, Air and Water Resources, University of California, Davis; Phil Wood, U.S. Environmental Protection Agency; Glenn B. Sawyer, California Department of Water Resources; Richard J. Wagner, California Department of Water Resources; Gylan L. Dickey, U.S. Soil Conservation Service; Neil W. Schild, U.S. Bureau of Reclamation; "Report of California Interagency Irrigation Water Use and Management Committee" (Sacramento, Soil Conservation Service, preliminary edition, 1978), p. 16.

31. U.S. Bureau of Reclamation et al., *supra note* 25, at 2.3, 4.1–4.2.
32. U.S. Bureau of Reclamation, *Report of California Interagency Irrigation Water Use and Management Committee* (Sacramento, May 1978).
33. Comptroller General, *supra* note 21, at 15.
34. *Id.* p. 16.
35. Louis A. Beck, Director, San Joaquin Valley Interagency Drainage Program, Fresno, California, interview with David Sheridan, April 11, 1979.
36. Council on Environmental Quality, *supra* note 2, at 380–82.
37. U.S. Department of Agriculture, *supra* note 24, at 55.
38. *Ibid.*
39. Robert Webb, interview with David Sheridan, September 9, 1979.
40. U.S. Department of Agriculture, *supra* note 24, at 55.
41. *Id.* p. 56.
42. U.S. Geological Survey, "Field Observations of the December, 1977 Windstorm, San Joaquin Valley, California" (Menlo Park, 1978), pp. 1, 8, 10, 18–19.
43. Howard Wilshire, U.S. Geological Survey, Menlo Park, California, interview with David Sheridan, November 20, 1979.
44. U.S. Geological Survey, *supra* note 42, at 19, 17.
45. *Id.* p. 55.
46. *Id.* p. 7.
47. U.S. Department of Agriculture, *supra* note 24, at 107.
48. Comptroller General of the United States, *To Protect Tomorrow's Food Supply, Soil Conservation Needs Priority Attention,* CED 77–30 (Washington, D.C.: U.S. Government Printing Office, 1977), p. 5.
49. *Ibid.*
50. John F. McCauley et al., "The U.S. Dust Storm of February 1977," preliminary report, U.S. Geological Survey, Flagstaff, Arizona, p. 22.
51. John Knapp, Soil Conservation Service agronomist, La Junta, Colorado, interview with David Sheridan, April 18, 1979.
52. *Ibid.*
53. Texas Crop and Livestock Report Service, *1977 Texas Agricultural Cash Receipts Statistics* (Austin: Texas Department of Agriculture), pp. 16–17; James McGehee, Gaines County Executive Director, Agricultural Stabilization and Conservation Service, Seminole, Texas, interview with David Sheridan, April 20, 1979.
54. 16 U.S.C. §§ 590p, 590q–3.
55. Pub. L. 96–263, 94 Stat. 438 (1980) (amending the Soil Conservation and Domestic Allotment Act, Pub. L. 91–113, 83 Stat. 187–90 (1969)).
56. Information provided by the U.S. Department of Agriculture.
57. Comptroller General, *supra* note 48, at 53.
58. Council on Environmental Quality, *supra* note 2, at 376–83.
59. Comptroller General of the United States, *Reserved Water Rights for Federal and Indian Reservations: A Growing Controversy in Need of Resolution,* CED 78–176 (Washington, D.C.: U.S. Government Printing Office, 1978), pp. 33–34.
60. Anne E. Bell and Shelly Morrison, *Analytical Study of the Ogallala Aquifer in Gaines County, Texas,* Report 227 (Austin: Texas Department of Water Resources, 1979), p. 6.
61. Walter Bertsch, U.S. Soil Conservation Service, Seminole, Texas, interview with David Sheridan, April 19, 1979.
62. Anne E. Bell and Shelly Morrison, *supra* note 60.
63. See definition of the Department of Agriculture in 7 CFR § 657.5 (1978), 43 Fed. Reg. 4030–4033.
64. U.S. Department of Agriculture, "Soil and Water Resources Conservation Act—1980 Appraisal Review Draft—Part 1," draft, pp. 2–9, 2–10.
65. R.I. Dideriksen, A.R. Hidlebaugh, and K.O. Schmude, "Trends in

Agricultural Land Use," in Max Schnepf, ed., *Farmland, Food and the Future* (Ankey, Iowa: Soil Conservation Society, 1979), pp. 21–22.

66. U.S. Department of Agriculture, *Agricultural Outlook,* AO–58 (Washington, D.C., 1980), p. 53.
67. U.S. Department of Agriculture, "Model Solutions to Resource Conservation Act Dilemmas," to be published with the final RCA reports.
68. National Association of Conservation Districts, *Conversion of Agricultural Land: A Look at Issues by Conservation District Officials* (Washington, D.C., 1979).
69. *Ibid.*
70. Council on Environmental Quality, *supra* note 2, at 478.
71. W. Wendell Fletcher and Charles E. Little, "Land Impacts of Rural Population Growth," prepared for the Council on Environmental Quality, 1980.
72. Raymond I. Dideriksen and R. Neil Sampson, "Important Farmlands: A National Viewpoint," *Journal of Soil and Water Conservation* 31:196 (1976); see also Thomas Platt, "The Effects of Urbanization on the Loss of Farmland at the Rural-Urban Fringe: A National and Regional Perspective," Resource Science Research Institute Discussion Paper Series 94 (Philadelphia, 1976), p. 26.
73. W. Wendell Fletcher and Charles E. Little, *supra* note 71, at 23.
74. Allen R. Hidlebaugh, National Agricultural Lands Study, "An Analysis of the Probable Cropland Availability in the United States, 1980–2030," 1980.
75. Gladys K. Bowles and Calvin L. Beale, "Commuting and Migration Status in Nonmetro Areas," *Agricultural Economics Research* 32(8): 8–20 (1980).
76. *Ibid.*
77. U.S. Department of Housing and Urban Development, *The President's National Urban Policy Report,* 628–577/2660 (Washington, D.C.: U.S. Government Printing Office, 1980).
78. *Id.* pp. 3–18.
79. *Ibid.*
80. Executive Office of the President, Office of Management and Budget, *Special Analyses—Budget of the United States Government—Fiscal Year 1981* (Washington, D.C.: U.S. Government Printing Office, 1980), p. 230.
81. Joe Berger, "The New Boss at D.O.T.," *Mass Transit* 7:13 (1980), quoting Neil Goldschmidt, Secretary of Transportation.

Chapter 9

NEPA

The Council's regulations implementing the National Environmental Policy Act took effect on July 30, 1979, completing a process begun by President Carter to improve compliance with NEPA procedures. The purposes of the regulations are to make environmental assessments and impact statements more useful to decisionmakers and the public and to reduce paperwork and delays. As CEQ stated in the preamble to the regulations, NEPA's purpose in requiring the analysis of the environmental effects of major U.S. government actions before they are taken is "not to generate paperwork—even excellent paperwork—but to foster excellent action." [1]

The NEPA regulations, reprinted in Appendix E, require that every agency adopt its own procedures by July 30, 1979, tailoring the regulations to its activities and programs. Specifically, agency supplemental procedures must ensure that

- The NEPA process is linked directly to decisionmaking, so that agency officials use and consider environmental documents in their decisionmaking
- Agency actions are classified as one of three types: those normally requiring a full environmental impact statement (EIS), those normally requiring at least an environmental assessment, and those categorically excluded from the NEPA process
- The NEPA process for projects subject to federal permits or approvals begins early
- Interested persons know where to obtain information and status reports on EISs and on other elements of the NEPA process
- Supplemental environmental impact statements, if any, are introduced into the formal administrative record—in cases for which formal records exist.

The regulations uniformly interpret NEPA procedural requirements for all federal agencies. Agency procedures apply the regulations to agency review of proposed actions and to subsequent decisions. Eighty-nine federal departments, component bureaus, and agencies have published or are scheduled to publish final supplemental NEPA procedures. The list is printed in Appendix F.

EVALUATING THE NEPA REGULATIONS

That the regulations are improving decisions, reducing delay, and reducing paperwork was evidenced in an informal Council survey of agency EISs prepared in the first 6 months after the regulations went into effect. The survey of more than 250 EISs prepared by 25 agencies found:

- Almost all EISs are within the 150-page limit
- A majority of EISs are analytic rather than encyclopedic, focus on alternatives analysis, and relate alternatives to environmental effects
- EISs are easier to read and understand and will therefore be more useful to agency decisionmakers
- In general, the agencies are preparing good records of decisions at the conclusion of the EIS process, indicating what mitigation and monitoring measures will be taken, but they often fail to identify clearly the environmentally preferable alternative, as required by the regulations.

Despite positive evidence of reform, many EISs are prepared under the old format prescribed by the CEQ guidelines, particularly by the independent regulatory agencies. Their EISs tend to be overly technical, encyclopedic rather than analytic, and difficult to understand.

LIST OF FEDERAL AGENCIES

To assist the agencies, the Council listed in the *Federal Register* all the federal agencies and federal-state agencies with jurisdiction by law or with special expertise on environmental quality issues.[2] The agencies are organized under pollution control, energy, land use, and natural resource management, with further subdivisions in each category. The list will help federal decisionmakers identify the lead agency and cooperating agencies when more than one is involved. It will aid private parties whose activities are subject to federal regulation in identifying the federal permitting, licensing, or other approval requirements. Further, the list will help the agencies and the public to participate more effectively in the NEPA process by helping them identify agencies that may be involved in a particular proposal and that should be asked to comment on a draft EIS.

THE BENEFITS OF NEPA AND THE REGULATIONS

Federal agencies have reported savings and economic and environmental benefits from NEPA. The Environmental Protection Agency (EPA) analyzed the benefits and costs of applying NEPA to its waste water treatment construction grants program, one of the largest federal public works programs, and to its National Pol-

lutant Discharge Elimination System (NPDES) permit program for all point sources of water pollution.[3] Data were gathered from EPA staff interviews and reviews of project files in EPA regional offices. EPA evaluated 60 EISs, 51 for waste water treatment projects and 9 for NPDES permits (for example, new coal power plants). Information related to four indicators of NEPA benefits and costs:

- Project changes as a result of the EIS—for example, whether the size of the facility was reduced or increased, whether more costly sludge disposal was required, and whether interceptor sewers were made compatible with controlled local and regional growth
- Protection or enhancement of environmental resources as a result of the EIS—evaluated resources included wetlands, floodplains, prime agricultural lands, open space, endangered species and their habitat, and aquifer recharge areas
- Public activities undertaken as a result of the EIS—for example, public hearings, meetings, special mailings, media supplements
- Costs of the EIS process, including project cost changes—for example, increased costs associated with project delay and with mitigation or reduced costs related to the EIS.

At least one major change was made in all but 1 of the 51 waste water treatment plant proposals because of an EIS. For 40 plants, EISs resulted in protection of between 2 and 10 environmental resources, both during and after construction. At least one major project change was also made in all but one of the nine industrial facilities requiring NPDES new source permit EISs. In fact, one EIS resulted in three changes. Protection of one or more environmental resources was attributable to the NPDES EISs in all but one project.

The number of public participation events for all EPA environmental impact statements averaged 2.3 per EIS—3.1 for waste water treatment projects and 1.3 for NPDES permits.

For the 50 waste water treatment plants,[4] the average construction cost was nearly $83 million. For the EIS, the average cost was $158,585. Thus the ratio of EIS cost to project cost was less than one-fifth of 1 percent. Only rough estimates were available on the cost of preparing NPDES permit EISs because most of the information came from the applicants who were paying for EIS preparation. The estimates show that the average industrial facility cost was $433 million and that the cost ratio was under one-tenth of 1 percent.

After calculating project cost increases resulting from an EIS[5] and project cost savings resulting from an EIS,[6] EPA found that even though costs increased in a majority (31) of the plants, the savings in the 19 other plants, where costs were reduced, more than offset total increases. The net savings as a result of EISs for 49 plants was $34.5 million. One EIS achieved extraordinary savings of $438.4 million because a plant was redesigned on a much smaller, more appropriate scale than the one originally proposed.

The EPA analysis concludes that the EISs substantively changed decisionmaking. They were not simply a pro forma paperwork exercise. Significant long-term protection and enhancement of environmental resources were attributable to the EIS. Thus the EIS process protects the environment at the same time that it helps improve the cost-effectiveness of projects.

The Forest Service, the National Oceanic and Atmospheric Administration, and other agencies have found that implementing the new NEPA regulations helped them integrate the NEPA process with their planning process. This integration furthers a major goal of NEPA—to make environmental analysis a routine part of agency operations planning in the same way that economic and technical analyses are a part of planning. But as these processes are integrated, it will become increasingly difficult to separate out savings achieved by preparing an EIS and to determine the EIS- and NEPA-related costs.

Application of the EIS process [7] to proposed federally aided highway projects in the Pacific Northwest demonstrates quite a different kind of NEPA benefit. Preparation of EISs ultimately led to the provisions of recreation facilities and protection of open space and historic areas. Altogether, the Department of the Interior's Heritage Conservation and Recreation Service (HCRS) valued these amenities at more than $200 million.[8] Application of NEPA to the highway planning process and review by agencies such as HCRS produced the following mitigation measures along a 6.9-mile stretch of Interstate 90 between Seattle and nearby Bellevue: creation of a 180-acre greenbelt along the highway, protection of two historic houses, and a finding that a bridge and tunnel portals of the existing road are eligible for protection by registry on the National Register of Historic Places. Comments by government agencies and the public on other federal highway EISs have brought about public easements for streamside access, realignment of proposed highway routes through recreation areas, and replacement of recreation areas lost to highways.

Other federal agencies, including the Department of Housing and Urban Development, the Army Corps of Engineers, and the Department of Energy, report that EISs continue to indicate the need and provide the basis for project changes that result in environmentally sound decisions.

ENVIRONMENTAL ANALYSIS OF NUCLEAR POWER PLANT ACCIDENTS

The Council reviewed the Nuclear Regulatory Commission (NRC) environmental analysis of nuclear power plant accidents and found it seriously deficient.[9] Since 1971, the discussion in nuclear power plant EISs of possible nuclear accidents and their environmental

effects has been perfunctory, standardized, and uninformative. Despite the diversity of size, design, and location of nuclear power plants licensed by the NRC over the years, virtually every EIS contains "boilerplate" language in an unvarying format. The typical EIS does not consider or analyze the possibility of a major accident such as a core meltdown even though these "Class 9" accidents (as they have been called by the NRC) have the potential for the most environmental harm and are of great public concern.

At the conclusion of its review, the Council recommended a new NRC policy to assess the probability of a major nuclear accident for each nuclear plant. The Council urged the NRC to follow the risk assessment analysis requirements in the NEPA regulations, particularly the requirement for a worst case analysis. Since then the NRC has issued a Statement of Interim Policy withdrawing its earlier risk assessment standard.[10] The Interim Policy requires EISs to consider site-specific environmental impacts attributable to nuclear plant accidents that can cause release of radiation or radioactive materials and accidents that can cause inadequate cooling of reactor fuel and lead to core meltdown. EISs must now consider both the probability of such releases and their environmental effects.

DEVELOPMENTS IN THE COURTS

The only Supreme Court opinion in the past year to address agency responsibilities under NEPA was *Strycker's Bay Neighborhood Center* v. *Karlen*.[11] The Court summarily reversed the judgment of the Court of Appeals for the Second Circuit which upheld a NEPA challenge to approval of New York City's West Side Urban Renewal Plan by the Department of Housing and Urban Development (HUD). NEPA applied because HUD approval is a condition for federal financing of low and moderate income housing built under the Plan. In reversing the appellate court, the Supreme Court reiterated principles that it had laid down in previous cases involving NEPA review of agency action.[12]

THE *STRYCKER'S BAY* CASE

The *Strycker's Bay* case originated in 1971 when a citizens' group challenged HUD's decision not to prepare an EIS on the Plan.[13] The Plan governs housing construction in the West Side Urban Renewal Area; changes in the Plan would permit construction of more low income housing and the admission of more low income occupants into existing buildings in the area.

Both the District Court and the Court of Appeals agreed that no EIS was required for HUD approval of the Plan. However, the Court of Appeals found HUD in violation of NEPA's Section 102(2)(E), which requires all federal agencies to "[s]tudy, develop,

and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources." [14] The court then remanded the action for further consideration of alternatives, in particular, alternatives that would avoid "concentration" of low income facilities in a single area.[15]

Following the remand, HUD conducted a detailed study of alternatives and concluded that the proposed 160-unit low income housing project on the preferred site was, on balance, an appropriate and sound response to the needs and conditions of the project area and that the project would have no significant environmental impacts. Although HUD acknowledged that two other alternative sites were "even more appropriate" than the selected site, the HUD study determined that countervailing considerations, such as the urgent need for low income housing, were sufficient to support approval of the proposed site.

The District Court, reviewing HUD's report, held that "HUD discharged its duty to examine alternatives with good faith objectivity." [16] The Court of Appeals, however, reversed and remanded, reinstating the injunction against the project.[17] Acknowledging that HUD had done a "careful analysis" and had "considered alternatives," the court nevertheless held that HUD's selection of the 160-unit alternative constituted impermissible "economic concentration" in violation of NEPA and that HUD's consideration of delays in preferring the 160-unit alternative was also "impermissible." The court then concluded that HUD had committed an error by not giving "determinative weight" to "environmental" factors.

On January 7, 1980, the Supreme Court reversed the Second Circuit Court of Appeals in a *per curiam* opinion, with Justice Marshall strongly dissenting. Referring to the long history of the litigation in which the Federal District Court had twice upheld HUD compliance with NEPA and relying on the Court's 1978 opinion in *Vermont Yankee Nuclear Power Corp.* v. *NRDC,*[18] the Supreme Court said:

> We [in *Vermont Yankee*] stated that NEPA, while establishing "significant substantive goals for the Nation," imposes on agencies duties that are "essentially procedural." As we stressed in that case, NEPA was designed to insure a fully-informed and well-considered decision but not necessarily "a decision that judges of the Court of Appeals or of this Court would have reached had they been members of the decisionmaking unit of the agency." [19]

Citing its earlier NEPA decision in *Kleppe* v. *Sierra Club,* the Supreme Court reiterated its position that a reviewing court cannot "interject itself within the area of discretion of the executive as to the choice of the action to be taken." [20] It is important to note that in *Kleppe* the Court emphasized the requirement of taking a "hard look" and carefully considering the environmental effects of the proposed action. The Court's citation to *Kleppe* and the facts of

Strycker's Bay show that HUD had fully considered the environmental effects. Concluding that "there is no doubt that HUD considered the environmental consequences of its decision," the Supreme Court summarily reversed the Second Circuit's judgment.[21]

Pointing out that the trial court had expressly found that HUD's decision was *not* arbitrary or capricious, the Court said:

> [O]ur reading of the opinion of the Court of Appeals [for the Second Circuit] satisfies us that it did not overturn that finding. Instead the appellate court required HUD to elevate environmental concerns over admittedly legitimate considerations. Neither NEPA nor the APA [Administrative Procedure Act, 5 U.S.C. Sec. 706] provides any support for such a reordering of priorities by a reviewing court.[22]

Both NEPA and the CEQ implementing regulations allow agencies to balance "other essential considerations of national policy" in making their decisions.[23] Had HUD acted in an arbitrary or capricious manner, however, the standards of judicial review under the Administrative Procedures Act (APA) would have applied.

Strycker's Bay does not forbid the reviewing court from setting aside or modifying agency action when there is substantial evidence in the record that the agency decision is arbitrary or capricious as tested by the APA and the substantive goals and policies of Section 101(b) of NEPA. In *Citizens To Preserve Overton Park* v. *Volpe*,[24] the Supreme Court made it clear that the arbitrary and capricious standard under the APA allows a court to consider only "whether the decision was based on a consideration of relevant factors and whether there has been a clear error of judgment." In NEPA cases this language has led to a formulation that, as Professor Rodgers described it, "approaches blackletter law on the scope of substantive review under NEPA: 'The Court must determine, according to the standards set forth in Section 101(b) and 102(1), whether the actual balance of costs and benefits was arbitrary or clearly gave insufficient weight to environmental values.' " [25]

Strycker's Bay does not change the reviewing court's duty to make a "searching and careful" judicial inquiry [26] to determine agency compliance with NEPA; to ensure that the agency has taken a "hard look" [27] at the environmental effects of its proposal; or, in appropriate cases, to set aside or modify agency action that is arbitrary, capricious, or an abuse of discretion; or to set aside or modify agency action in cases in which there are "substantial procedural or substantive reasons as mandated by statute." [28]

THE RARE II CASE

A significant court decision with nationwide repercussions on Wilderness Area legislation and National Forest planning actions was *California* v. *Bergland*,[29] decided in early 1980 by the District Court in the Eastern District of California. Here the court addressed the Forest Service's far-ranging Roadless Area Review and Evaluation

(RARE II) process for planning National Forest uses. Under RARE II, the Forest Service had studied and then classified 2,918 roadless areas (about 62 million acres) in three categories: "wilderness" areas, which would be recommended to the Congress for legislative inclusion in the Wilderness Preservation System; "nonwilderness" areas, which would be open to development without further consideration as wilderness; and "further planning" areas, whose future would be decided under ordinary forest planning procedures. Roughly 15 million acres were designated "wilderness," 36 million acres were "nonwilderness," and 10.8 million acres were in "further planning."

In *California* v. *Bergland,* the court forbade the Forest Service to allow any development in the 47 California areas designated "nonwilderness" under RARE II because NEPA had been violated during the RARE II process in three ways. First, the final EIS failed to examine in detail the wilderness values of specific roadless areas and to assess the site-specific impacts of opening areas to development through nonwilderness designation.

Second, the EIS failed to analyze a reasonable range of alternatives in the proposed disposition of RARE II areas. Of the 11 alternatives analyzed in the EIS, 10 allocated 34 percent or fewer of the areas to wilderness, and the 11th allocated 100 percent to wilderness—an allocation that the Forest Service conceded was unrealistic. The court concluded that the Forest Service's failure to explain why it did not examine any "intermediate" alternatives—allocating between 34 and 100 percent to wilderness—violated NEPA requirements to analyze reasonable alternatives.

Third, in several respects the Forest Service violated requirements of NEPA and the new CEQ regulations to solicit and consider public comment on RARE II proposals. The Forest Service proposal did not even appear until the final EIS was released in January 1979. Further, the Forest Service failed to respond to public comments on specific proposed RARE II areas. Although the Forest Service expressly solicited such comments in the draft EIS, in the final EIS it responded only to general comments about the overall RARE II process. In addition, the court held that the Forest Service improperly changed its evaluation of comments. The draft EIS indicated that the Forest Service preferred thoughtful letters and quality responses, but in the final EIS, it stressed quantity of signatures and not quality of content. The case is now on appeal in the Ninth Circuit.

The Court of Appeals for the District of Columbia Circuit dealt with quite a different NEPA issue in *Defenders of Wildlife* v. *Andrus*[30]—whether a federal agency's *failure* to take a particular action is subject to NEPA. At issue was the Department of the Interior's acquiescence in Alaska's program to shoot wolves from aircraft in much of the state's interior, which includes federal lands. This issue had been in litigation for some time in federal court in the

District of Columbia and Alaska. One court held that the Secretary must assess the environmental effects of a decision *not* to take action;[31] the second court held quite the opposite.[32]

When Alaska again proposed a wolf kill program on federal lands in 1979, the Defenders of Wildlife again sued in the District Court for the District of Columbia, and once again the court enjoined the action, stating that the Interior Secretary's nonexercise of his power to stop the killing required an EIS. The Court of Appeals reversed, holding that a federal agency must take some "overt act" in furtherance of a particular goal for a "federal action" to be within the meaning of NEPA. The court relied on a CEQ opinion interpreting "major federal action" under the new NEPA regulations.[33] The court reiterated its holding in *Andrus* v. *Sierra Club,* that the CEQ interpretation of NEPA is entitled to "substantial deference."[34] The CEQ opinion states in part that

> [t]he reference in [Section 1508.18] to "a failure to act" was not intended by the Council to require the preparation of an EIS where no Federal decision was required and none had been made. The phrase "failure to act" was intended rather to describe one possible outcome in those situations where a Federal decision had been or was required to be made.
>
> We recognize that the practical effect of a decision not to act and no decision at all is the same in the circumstances of this case. In both cases State activities on Federal lands may proceed.[35]

Thus the Court relied on a CEQ interpretation that in some instances a failure to act may require an EIS, at least when a major action by a federal agency is required or is proposed.

Another significant decision involving NEPA regulations is *State of North Dakota* v. *Andrus,*[36] in which Interior's legislative proposal for joint federal-state cost sharing for water resources projects was challenged on NEPA grounds. In its environmental assessment, Interior determined that an EIS was not necessary because the impact of the policy was primarily financial and political. The court agreed, holding that an EIS on the proposal would largely involve speculation about impacts, primarily the economic impacts. The court noted that an EIS on a specific project would be prepared and that an EIS at that stage would be more meaningful. In its decision, the court referred to the new CEQ regulations which are now binding "on all Federal agencies" and especially to their definition of human environment, which states that "economic or social effects are not intended by themselves to require preparation of an environmental impact statement."[37]

A fourth important case is *Citizens for Responsible Growth* v. *Adams,*[38] decided by the federal District Court in New Hampshire. Three federal agencies, the Economic Development Administration (EDA), the Farmers Home Administration (FmHA), and the Federal Aviation Administration (FAA), were providing Lebanon, New Hampshire, financial assistance on separate but related components of a proposed regional air terminal-industrial park project.

EDA and FmHA were funding construction of a new terminal building, development of the industrial park, and related improvements such as streets, sewers, and lighting. FAA funding was sought to expand airport runways. Looking only at the environmental impacts of the parts of the project that they were financing, the agencies decided that their actions would not have significant environmental effects. The citizen plaintiffs, joined by the Vermont Attorney General, argued that an EIS was required because the three agency actions were related and must be evaluated as a whole. The court agreed, relying in part on the definition of "major federal action" in Section 1508.18 of the CEQ regulations. EDA had tried to justify its finding of no significant impact on the basis of its agreement with the airport authority to mitigate certain adverse environmental effects stated in a plan to be approved by EDA. The court rejected this attempt to postpone application of NEPA:

> In short, the agency cannot bargain to waive NEPA compliance: "the NEPA requirement exists to protect the public at large and other interested agencies." [39]

The court issued a preliminary injunction against further federal participation in the project pending preparation and consideration of an EIS.

EIS ALTERNATIVES AND THE NEED FOR AN EIS SUPPLEMENT

Grazing Fields Farm v. *Goldschmidt*,[40] decided by the First Circuit Court of Appeals, involved the extent of the Federal Highway Administration's (FHWA) duty to consider alternative highway alignments in an environmental impact statement. The plaintiffs had attempted to convince state and federal highway officials that a proposed highway through their property should be routed to avoid serious interference with important wetlands and other adverse environmental effects, and they proposed a specific alternative route. However, the EIS did not include that alternative, and the FHWA would not agree to prepare a supplemental EIS on the alternative. Instead, FHWA directed its consulting firm to prepare a study of the plaintiffs' preferred alternative, which was later rejected because it would lengthen the highway by a half mile. The question was whether the FHWA could rely on documents and studies other than the EIS to demonstrate consideration of alternatives as required by NEPA. The court held that the FHWA could not—that the public is effectively prevented from reviewing and commenting on alternatives or other analyses not found in the EIS.

ENERGY RESOURCES

Several significant NEPA decisions concerned the development and use of energy resources—outer continental shelf (OCS) oil and gas development, nuclear wastes, and nuclear power plant licensing

issues. The courts allowed the oil and gas lease sale in Georges Bank off Massachusetts to go forward and held up but eventually allowed the sale of leases in the Beaufort Sea.

The Georges Bank case has a long history and generated great public interest because it involved extensive oil and gas activity in one of the world's most important commercial fisheries. In January 1978, the U.S. District Court in Massachusetts enjoined the Secretary of Interior from accepting bids for an OCS lease sale in Georges Bank.[41] The Circuit Court of Appeals vacated that injunction but found violations of the OCS Lands Act and NEPA. In particular, the EIS inadequately discussed the alternative of protecting Georges Bank as a marine sanctuary and inadequately analyzed the potentially disastrous impacts of oil spills on Cape Cod.[42]

Interior later rescheduled the lease sale for November 6, 1979, and published a draft supplemental EIS addressing the inadequacies noted by the court. Following its circulation for comment, a final supplement EIS was issued. Massachusetts then sued Interior on the adequacy of the EIS supplement, but the U.S. District Court refused to stop the sale, holding that the EIS supplement adequately examined the marine sanctuary alternative.[43]

North Slope Borough v. *Andrus* related to a federal-state lease sale scheduled for December 1979 in the Beaufort Sea. The projected recoverable oil and gas reserves from the sale area are very high. Opponents claimed that drilling in the extremely harsh conditions of the Beaufort Sea is exceptionally risky for a pristine, fragile, and valuable environment. At particular risk were the endangered bowhead whales—already the subject of intense controversy because they provide subsistence hunting for the Inupiats (for further discussion, see Chapter 1, The Global Environment).

A consortium of environmental groups, Alaska natives, and the Alaska North Slope Borough filed three separate suits to stop the proposed December 1979 sale. The suits alleged violations of NEPA, the Endangered Species Act, and the Marine Sanctuaries Act, among other federal statutes.

On December 7, 1979, the U.S. District Court in the District of Columbia denied the plaintiffs' motion for a preliminary injunction to halt the sale,[44] thus allowing it to be held on December 11. However, the court expedited trial of the case in order to rule before lease agreements could be concluded. On January 22, 1980, the court granted an injunction barring Interior from accepting bids from the sale and executing leases. The injunction was based on violations of the Endangered Species Act and NEPA.[45] The court held that the EIS failed to discuss alternative measures to mitigate adverse environmental impacts and to analyze the alternative of managing the area as a marine sanctuary. Further, the EIS did not adequately address onshore production, transportation facilities, and other cumulative impacts of the lease and related activities on the culture and environment of the region. The court noted that the

impacts would be a real threat to the way of life of the Inupiats along the North Slope. The court also noted that Interior's worst case analysis in the EIS would have been inadequate had the new NEPA regulations been applicable. On July 10, 1980, the Court of Appeals for the District of Columbia issued an order vacating the injunction.[46] The following day the Interior Department accepted bids and specifically authorized leases to engage in pre-exploration activities, including geological surveys on the 24 Beaufort Sea tracts involved.

With regard to nuclear energy, the Court of Appeals for the District of Columbia, in *NRDC* v. *NRC*,[47] held that the Energy Research and Development Administration (a predecessor of the Department of Energy) violated NEPA by failing to prepare an EIS for its approval of nuclear waste storage tanks at Hanford, Washington, and on the Savannah River, South Carolina, particularly with respect to design and safety features that could have been incorporated.

Conversely, in *State of Minnesota* v. *NRC*,[48] the D.C. Circuit Court held that the NRC need not consider the availability of long-term onsite nuclear waste storage facilities at the expiration of licenses when it authorized amendments to operating licenses for two nuclear power plants. However, the court noted that the long-term waste repository issue was closely related to the long-continued administrative proceeding involving the environmental impacts of the nuclear fuel cycle. It therefore remanded the issue to the NRC for further consideration of the specific problem isolated by petitioners —whether there is reasonable assurance that an offsite storage solution will be available by the years 2007-2009, when the plants' operating licenses expire and, if not, whether there is reasonable assurance that the fuel can be stored safely at the sites beyond those dates.

In the controversial Seabrook, New Hampshire, nuclear power plant case,[49] the Court of Appeals for the First Circuit examined the adequacy of the EIS prepared by the NRC. The court held that the NRC did not violate NEPA when it declined to compare the Seabrook site with other alternative sites not identified in the EIS. In particular, the court faulted the petitioners for not bringing their preferred alternative site in southern New England to the Commission's attention in sufficient detail during the EIS review process.

Another important NEPA decision concerned areawide planning and development. In *Atlanta Coalition on Transportation* v. *Atlanta Regional Commission*,[50] the Fifth Circuit held that the Federal Highway Administration need not prepare an EIS on the regional transportation development plan (RDP) required under federal law for the Atlanta metropolitan area because the RDP was proposed by state and local authorities, is not reviewed by any federal agency, and does not obligate any federal funds. The court was careful to point out, however, that a regional or comprehensive

EIS prepared by the FHWA may be required in some instances, such as where proposed transportation projects are sufficiently related to require a program EIS.

PROTECTION OF ENVIRONMENTALLY SENSITIVE AREAS

Several decisions in the past year relate to protection of environmentally critical areas such as wildlife habitat, forest preserves, and coastal resources. These decisions involved the relationship between NEPA and other federal statutes and a judicial interpretation which gives protection to the environment.

In *New England Power Co.* v. *Goulding*,[51] the court upheld the adequacy of a General Services Administration (GSA) EIS and decision to transfer excess naval properties near Narrangansett Bay, Rhode Island, to federal and local agencies for wildlife, marine sanctuary, park, and recreational purposes rather than to transfer part of the property to the New England Power Company (NEPCO) for a proposed nuclear power plant. NEPCO argued that the power plant could coexist with the proposed wildlife sanctuary. However, the GSA Administrator drew on the EIS and other relevant documents and determined in his record of decision that the sensitive ecological resources in the area precluded any large-scale construction project such as a nuclear power plant. Reading NEPA and the Federal Property and Administrative Services Act[52] together, the court upheld the Administrator's priorities favoring protection of the natural and environmental resources.

In *United States* v. *Richardson*,[53] the Ninth Circuit Court of Appeals construed the language and legislative history of federal statutes governing mining in the National Forests[54] together with the goals and policies in NEPA's Section 101(b) in upholding a permanent injunction against unreasonable and environmentally destructive blasting and bulldozing by a mining claimant on federal public land within the Gifford Pinchot National Forest in Washington.

EIS COSTS

The courts also addressed the question of who pays for the cost of preparing EISs. In *Mississippi Power and Light Co.* v. *NRC*,[55] the Fifth Circuit Court of Appeals considered whether the NRC could recover the full cost of EIS preparation as part of the fee charged to applicants for nuclear power plant construction licenses. The court ruled that under the Independent Offices Appropriation Act,[56] the NRC could charge license applicants the full cost of processing the application, including the full cost of preparing and distributing the EIS. A similar case was *Alumet* v. *Andrus*,[57] in which the Tenth Circuit Court of Appeals, interpreting provisions of the Federal Land Policy Management Act,[58] upheld Interior's right to reim-

bursement for some of the costs—that portion incurred for an EIS for a right-of-way over public lands.

NEPA LITIGATION

During 1979, citizens, environmental groups, state and local governments, and businesses challenged federal actions under NEPA in 139 lawsuits. Five federal agencies were sued most frequently, accounting for 102 cases (73 percent): the Department of Transportation with 33 cases (24 percent), the Department of Housing and Urban Development with 23 cases (17 percent), the Department of the Interior with 19 cases (14 percent), the Department of Agriculture with 14 cases (10 percent), and the Department of Defense with 13 cases (10 percent).

The Civil Aeronautics Board (CAB), the Federal Railroad Administration (FRA), and HUD had more NEPA lawsuits than in previous years. The six CAB suits involved complaints about the failure to prepare an EIS and consider increased noise when CAB approved airline mergers and authority to operate at new fields. The seven FRA suits all involved the same federal action—FRA's recommended route structure for a national railroad to be operated by the National Railroad Passenger Corporation. Under the Amtrak Improvement Act of 1978,[59] FRA's recommended route structure will go into effect automatically unless it is modified by the Congress. The NEPA suits contested FRA's finding that the recommended route structure would not have significant environmental effects. For HUD, the 23 NEPA cases nearly doubled its 1978 level, primarily because of the sizable increase in the number of lawsuits contesting HUD approval for low and moderate income housing projects and for projects under its Urban Development Action Grant (UDAG) and Community Development Block Grant Programs. Virtually all the HUD litigation was based on allegations that HUD failed to prepare a required EIS.

The most frequent allegation in 1979 NEPA cases, comprising 61 percent of the total number, is that an agency was required to prepare an EIS for a proposed action but failed to do so. In 25 percent of the NEPA cases, the principal complaint was legal inadequacy of an EIS. In the remaining cases, miscellaneous NEPA issues included failure to comply with Section 102(2)(E) and to implement mitigation measures which were identified in the final EIS.

As shown in Table 9–1, the most common types of federal actions or projects litigated were highway and road construction projects (16 cases, 11 percent), public lands actions (15 cases, 10 percent), mass transit actions (13 cases, 9 percent), energy projects (13 cases, 9 percent), water and sewage treatment projects (10 cases, 7.5 percent), and subsidized housing projects (10 cases, 7.5 percent).

Table 9–1

NEPA Litigation, 1979

Type of federal action or project	Number of suits filed (139)	Cases resulting in injunctions (average duration)
Highway and road construction	16	2 (6 mos)
Actions involving public lands (other than energy and water)	15	2 (4.5 mos)
Mass transit	13	0
Energy projects	13	1 (5.5 mos)
Water and sewage treatment projects	10	0
Subsidized housing	10	0
Policies, programs, plans, regulations, and standards	10	1 (3 mos)
Projects affecting wetlands and water bodies	9	1 (12 mos)
Air transportation activities	9	0
Wildlife-related activities	9	2 (12 mos)
Urban renewal-development actions	8	1 (3 mos)
Actions affecting historic sites	8	0
Subsidized commercial/industrial projects	7	1 (12 mos)
Actions involving toxic substances—pesticides	2	0
Military activities	2	1 (3 mos)
Miscellaneous	13	0
Total	154 •	12 (7 mos)

• Total exceeds 139 because some cases involved two or more categories of action.

During 1979, environmental groups were among the plaintiffs in 36 cases (20 percent), citizen groups and individuals in 36 cases (20 percent), business and industry in 34 cases (19 percent), directly affected property owners and residents in 31 cases (17.5 percent), local governments in 18 cases (10 percent), state governments in 11 cases (6 percent), and labor unions, Indian tribes, and other plaintiffs in 11 cases (6 percent).

Approximately 1,400 environmental impact statements (about evenly divided between drafts and finals) were prepared and filed with the Environmental Protection Agency by some 89 federal agencies and component bureaus during 1979. At the same time, thousands of environmental assessments were also prepared by these agencies.

REFERENCES

1. 40 C.F.R. § 1500.1(c).
2. 45 Fed. Reg. 57488–513 (1979).
3. Randal Scott, U.S. Environmental Protection Agency, "Evaluation of the Environmental Protection Agency's Non-Regulatory Environmental Impact Statement Preparation Programs" (Washington, D.C., draft, September 1979).
4. Of the total 51 waste water treatment plant EISs, 1 lacked sufficient cost data for analysis.

5. EIS cost increases are any cost increases that result from change in a proposed project in the facility plan (also called the "Step 1 Plan") submitted under Section 201 of the Clean Water Act to the project recommended in the final EIS. When the facility plan and EIS are prepared jointly ("piggybacked EISs"), EIS cost increases are increased project costs attributable to changes sponsored by the EIS consultant. When EIS preparation delayed approval of construction financing, a penalty of 8.5 percent compounded annually was assessed on the total project cost. Scott, *supra* note 3, p. 13.
6. EIS cost savings are the cost of the project as proposed in the facility plan less the cost of the alternative selection in the final EIS. *Ibid.* The monetary value of protecting and enhancing environmental resources and increasing public participation as a result of the EIS process were not included in the EPA cost change calculations because of the difficulty of assigning dollar values. However, EIS cost increases may also be regarded as benefits to the extent that they constitute mitigation measures to protect the environment. See text at notes 6 and 7.
7. In concert with other applicable environmental review requirements, principally the Department of Transportation Act of 1966.
8. The Seattle regional office of HCRS documents mitigation of highway project impacts on park and recreation lands in its region in excess of $200 million. All of this amount is nonrecreation funds. The costs to HCRS and its predecessor agency averaged $20,000 per year for salaries of agency staff reviewing highway EISs, preparing comments and conducting other environmental reviews.
9. Environmental Law Institute, "NRC's Environmental Analysis of Nuclear Accidents: Is It Adequate," prepared for the Council on Environmental Quality (Springfield, Va.: National Technical Information Service, 1980).
10. 45 Fed. Reg. 40101 (1980).
11. *Strycker's Bay* v. *Karlen,* 100 S. Ct. 497, 13 ERC 2157 (1980).
12. *See Kleppe* v. *Sierra Club,* 427 U.S. 390, 410 n. 21 (1976); *Vermont Yankee Nuclear Power Corp.* v. *NRDC,* 435 U.S. 519 (1978).
13. HUD had concluded that its approval and financing under the Plan would not have a "significant adverse impact on the environment"—therefore required no EIS.
14. NEPA has two requirements for the study of alternatives, § 102(2)(C)(iii) as part of an EIS and § 102(2)(E) of broader application.
15. *Karlen* v. *Harris,* 590 F.2d 39, 45 (2d Cir. 1978).
16. *Trinity Episcopal School Corp.* v. *Harris,* 445 F. Supp. 204, 220, 12 ERC 1281, 1293 (S.D.N.Y. 1978).
17. 590 F.2d at 45.
18. 435 U.S. 519 (1978).
19. 100 S. Ct. at 499–500, 13 ERC at 2159.
20. *Id.* at 500, 13 ERC at 2159.
21. *Ibid.*
22. *Id.* at 500 n. 2, 13 ERC at 2159 note.
23. National Environmental Policy Act. § 101(b). See 40 C.F.R. § 1505.2(b); preamble to regulations, 43 Fed. Reg. 55978, 55985–86 (1978). *See also Andrus* v. *Sierra Club,* ___ U.S. ___, 47 USLW 4676, 13 ERC 1161 (1979).
24. *Citizens To Preserve Overton Park, Inc.* v. *Volpe,* 401 U.S. 402, 416 (1971).
25. William Rodgers, *Environmental Law* (St. Paul: West Publishing Co., 1977) p. 744, quoting *Environmental Defense Fund* v. *Corps of Engineers* (*Gillham Dam*), 470 F.2d 289, 300 (8th Cir. 1972), quoting *Calvert Cliffs' Coord. Comm'n.* v. *AEC,* 449 F.2d 1109, 1115 (D.C. Cir. 1971). See Council on Environmental Quality, *Environmental Quality —1977: The Eighth Annual Report of the Council on Environmental*

Quality (Washington, D.C.: U.S. Government Printing Office, 1977), p. 121; Council on Environmental Quality, *Environmental Quality—1978: The Ninth Annual Report of the Council on Environmental Quality* (Washington, D.C.: U.S. Government Printing Office, 1978).

26. 401 U.S. at 415–16.
27. 427 U.S. at 410 n. 21.
28. 435 U.S. at 558.
29. *California* v. *Bergland,* 483 F. Supp. 465, 13 ERC 2203 (E.D. Cal. 1980).
30. *Defenders of Wildlife* v. *Andrus,* ___ F.2d ___, 10 ELR 20163 (D.C. Cir. 1980).
31. *Defenders of Wildlife* v. *Andrus,* 455 F. Supp. 446 (D.D.C. 1978).
32. *Alaska* v. *Andrus,* 429 F. Supp. 958 (D. Alaska 1977), aff'd, 591 F.2d 537 (1979).
33. ___ F.2d ___, 10 ELR at 20168 n. 6.
34. *Andrus* v. *Sierra Club,* ___ U.S. ___, 99 S. Ct. 2335 (1979).
35. ___ F.2d ___, 10 ELR at 20168 n. 6.
36. *State of North Dakota* v. *Andrus,* 483 F. Supp. 255, 14 ERC 1230 (D. N. Dak. 1980).
37. *Id.* at 260, 14 ERC at 1235.
38. *Citizens for Responsible Growth* v. *Adams,* 477 F. Supp. 994, 10 ELR 20143 (E.D. N.H. 1979).
39. *Id.* at 1004, 10 ELR at 20148.
40. *Grazing Fields Farm* v. *Goldschmidt,* ___ F.2d ___, ___ ERC ___ (1st Cir. 1980).
41. *Comm. of Mass.* v. *Andrus,* Civil No. 78–1846 (D. Mass.).
42. *Commonwealth of Mass.* v. *Andrus,* 594 F.2d 872, 884–86 (1st Cir. 1979).
43. *Commonwealth of Mass.* v. *Andrus,* 481 F. Supp. 685, 13 ERC 1857 (D. Mass. 1979); *Conservation Law Foundation* v. *Andrus,* ___ F.2d ___, 13 ERC 1865 (1st Cir. 1979).
44. *North Slope Borough* v. *Andrus,* ___ F. Supp. ___, 13 ERC 2097, (D.D.C. 1979).
45. *North Slope Borough* v. *Andrus,* ___ F. Supp. ___, 13 ERC 2169 (D.D.C. 1980).
46. *North Slope Borough* v. *Andrus,* Civil No. 80–1148 (D.C. Cir. July 10, 1980). An opinion was issued later, on October 9, 1980.
47. *NRDC* v. *NRC,* 606 F.2d 1261, 13 ERC 1561 (D.C. Cir. 1979).
48. *State of Minn.* v. *NRC,* 602 F.2d 412 (D.C. Cir. 1979).
49. *Seacoast Anti-Pollution League* v. *NRC,* 598 F.2d 1221, 13 ERC 1243 (1st Cir. 1979).
50. *Atlanta Coalition* v. *Atlanta Regional Comm.,* 599 F.2d 1333, 13 ERC 1497 (5th Cir. 1979).
51. *New England Power Co.* v. *Goulding,* 486 F. Supp. 18, 13 ERC 2054 (D.D.C. 1979).
52. 40 U.S.C. § 471 *et seq.*
53. *United States* v. *Richardson,* 599 F.2d 290, 13 ERC 1773 (9th Cir. 1979).
54. 30 U.S.C. §§ 26, 612; 16 U.S.C. §§ 478, 551.
55. *Mississippi Power and Light Co.* v. *NRC,* ___ F.2d ___, 13 ERC 1569 (5th Cir. 1979).
56. 31 U.S.C. § 483a (1952).
57. *Alumet* v. *Andrus,* 607 F.2d 911 (10th Cir. 1979).
58. 43 U.S.C. §§ 1701, 1734(b), 1740, 1764(g).
59. 45 U.S.C. § 521 (1978).

Chapter 10

ECONOMICS

The Council estimates that the nation spent approximately $37 billion in 1979 to comply with federal environmental protection requirements—approximately 1.5 percent of the gross national product. It has been suggested that these expenditures may be slowing the growth of productivity. Although studies on the subject are not conclusive, available data suggest that environmental controls have had little impact on productivity.

Regulators have begun to consider economic incentives, including various offset policies which permit one industrial facility to increase air pollution emissions if another facility is willing to reduce them. The purpose of such policies would be to maintain desired levels of environmental quality at a lower overall cost to the nation. The Supreme Court has also begun to consider the issue of costs and benefits in reviewing cases involving environmental regulation.

REGULATION AND PRODUCTIVITY

Between 1948 and 1965, productivity in the United States—measured in terms of dollar value of output in the private sector (corrected for inflation) per hour of paid employment—grew at an average annual rate of approximately 2.5 percent. But in recent years, the rate of productivity growth has slowed substantially. Between 1965 and 1973, the average annual rate of growth was 1.6 percent per year. Between 1973 and 1978, it slowed to 0.8 percent per year.[1] In 1979, for only the second time since World War II, productivity actually fell by 0.9 percent (1974 was the other year). In the first half of 1980, productivity was declining at an annual rate of 1.7 percent. This continuing decline is of concern because increased productivity might make it possible for wages to rise without accompanying price increases. Productivity gains are thus a key element in the effort to control inflation.

Environmental and other forms of regulation are among the many factors that may have slowed productivity growth, but there are

others as well. The post-World War II rural-to-urban migration into new jobs in high-productivity manufacturing has ended. Large numbers of unskilled workers have entered the labor force, especially in the cities. Recent increases in energy prices may have encouraged the substitution of labor for energy-intensive capital equipment, and cyclical fluctuations in economic activity may have inhibited investment in new plants and equipment. Finally, there has been a shift in the economy from manufactured goods, which lend themselves to automation and thus increased productivity, to personal and other services, which generally do not.

It is important to determine what effect each of these factors has on productivity. Regulation may reduce productivity—as traditionally measured—if, for example, it diverts labor or capital from the production of goods to the production of safe workplaces or clean air or water.[2] Regulation might also slow productivity growth by delaying the construction of new industrial facilities or requiring their location in areas not convenient to suppliers or transportation lines, thus increasing costs. Similarly, uncertainty about future regulation could adversely affect the development of new and potentially productive technologies.

In any consideration of the relationship between regulation and productivity, however, it is essential to recognize that safe workplaces, clean air and water, unspoiled vistas, reclaimed land, and other benefits of environmental regulation are seldom included in estimates of national productivity. Thus imposition of air or water pollution abatement measures or other regulation will almost always produce a reduction in *measured* output but an increase in unmeasured benefits. Although reductions in productivity because of stagnation or decline in measured output are always of concern, they are acceptable if the unmeasured benefits of regulation are of greater value to society than those that are lost.[3] To the extent that this shift from measured to unmeasured output is responsible for declining productivity growth, the "problem" is only an artifact of our current measurement system.

In the past several years, economists have tried to determine statistically the individual contributions of the many factors that affect the rate of productivity growth, as traditionally measured. The first attempt to quantify the impact of environmental regulation on productivity growth appeared in 1978.[4] Using estimates of annual nonresidential business expenditures on pollution abatement (much like those presented later in this chapter), the study tried to determine the probable increase in productivity had the labor and capital used for pollution control been used for normal production instead. In its calculations, the study assumed that all resources devoted to pollution control would have been used for production and that those resources were of average productivity.

The study found that between 1967 and 1969, pollution abatement expenditures reduced the annual rate of growth of productivity

0.05 percent. Between 1969 and 1973, the effect was estimated at 0.10 percent, and between 1973 and 1975, 0.22 percent, i.e., the annual rate for 1975 would have been 0.822 rather than 0.080. The difference may seem small, but the size of the national income makes the absolute dollar amounts of output foregone substantial.

Both of the study's underlying assumptions are open to question, however. First, it is unlikely that all the money used for pollution control from 1967 to 1975 would have been spent on conventional production. Two of those years were recession years during which additional output would have been difficult to sell. Assuming a dollar-for-dollar displacement, then, probably leads to overestimation of the impact of regulation on productivity. Second, in general, the most productive resources are utilized first, the least productive, last. Thus if environmental regulation requires the diversion of existing labor and capital or the addition of new resources, the resources diverted are likely to be less productive than those devoted to the continued production of conventional output. In this respect also, it is likely that the study overestimated the adverse effects of regulation. These tendencies toward overestimation are offset to some extent by the fact that the study ignored the indirect, and perhaps significant, effects of regulation on productivity growth resulting from delay and siting effects, for example. It is thus difficult to draw definitive conclusions about the overall effects of regulation on productivity growth from this study.

The author of this study recently applied this same approach to more recent data on pollution abatement expenditures and data then available on GNP.[5] He calculated that between 1975 and 1978, expenditures on air and water pollution control and solid waste disposal reduced the rate of productivity growth 0.08 percent—about one-third the effect that these controls were thought to have had beween 1973 and 1975. The later calculations suggest that, although environmental regulation was still adversely affecting the rate of productivity growth in the late 1970s, as conventionally measured, its impact appears to be diminishing.

Numerous studies have attempted to quantify the effects of various factors on the slowdown in productivity growth.[6] These reviews suggest that some of the factors mentioned above may play larger roles in the decline in productivity growth than does environmental regulation. One review of the studies concluded that "in no case are pollution abatement regulations assigned more than 20 percent [or about 0.2–0.4 percent] of the responsibility for the decrease in productivity growth. The typical estimate of the role of environmental regulations is in the range of 5–15 percent [about 0.05–0.3 percent]."[7]

ECONOMIC INCENTIVES

Economic incentives may be effective in controlling pollution.[8] Possible incentives might be effluent charges (fees that must be paid

for each unit of pollution discharged) or marketable permits (legally enforceable entitlements to discharge that are fixed in number and exchangeable among polluters). Under certain conditions, both effluent charges and marketable permits are considered capable of vastly reducing the cost of improving environmental quality by taking advantage of variations in the costs of pollution control among dischargers—variations determined for the most part by the kind of raw material and process involved.

The Environmental Protection Agency's bubble and offset policies (the former allows a polluter to increase air emissions in one portion of a facility if it will reduce emissions elsewhere in the same facility, where costs may be lower; the latter permits an increase in emissions in one part of a geographic area if the polluter either reduces pollution elsewhere in that area or persuades another polluter to do so) are attempts to make use of economic incentives within the current regulatory framework.[9]

EPA is also considering several other incentive-based approaches. Transferable Emissions Reduction Assessments (TERAs) might be used if the emission controls required under State Implementation Plans (SIPs) were insufficient to meet the ambient air quality standards established under the Clean Air Act. Normally, the long process of a SIP revision would be necessary in such circumstances. Under the TERA approach, if a 10 percent reduction in overall emissions were required to meet the standards in a particular area, every pollution source in that region would be directed to cut its emissions 10 percent. But if one source could find another comparable source in the area able to reduce its emissions at a reasonable cost and then persuade that source to cut back 20 percent (in exchange, say, for financial considerations), the first source could avoid a cutback. In other words, firms could either make the reductions themselves or find offsetting reductions elsewhere. Such a procedure could have a cost-saving advantage and speed up the process of environmental improvement.

EPA is considering other incentive-based approaches to prevent significant deterioration (PSD) in areas where air quality is better than national standards. The Clean Air Act limits the extent to which air quality can be diminished in such areas. EPA must determine which sources may "consume" the incremental degradation that is permitted. This increment could be allocated on a first-come, first-served basis as sources apply for new permits. But other systems of allocation could also be used:

- Variable offsets—a potential new source could purchase some emissions entitlements from existing sources but less than it expects to emit (because some degradation is permitted)
- Emission density zoning—emissions entitlements would first be limited and then tied to particular parcels of land in PSD areas
- Emissions fees—potential sources would pay for the additional

degradation that they cause, and the price would rise as air quality approached the minimum permitted quality.

All three methods of allocating allowable increases in degradation are based on differences in the costs of pollution control among sources.

The Clean Air Act distinguishes between new and existing sources of pollution. In general, new sources are held to much stricter performance standards (new source performance standards, NSPS) than existing ones on the premise that environmental quality will gradually improve as existing sources are retired; in time, all sources will be subject to strict controls. Critics of this approach argue that it may unintentionally result in old plants being operated long past the point at which they would otherwise have been retired in order to avoid the strict controls on new sources.[10] There is little evidence available on the extent to which new plant construction is being delayed, but it may be worth thinking about ways to secure the same reductions in emissions that would result from strict NSPS without discouraging new plant construction.

One way to achieve this goal would be to allow new sources of pollution to operate under less stringent controls than those now required if they can secure equal or perhaps even greater than offsetting reductions from other new or existing sources in the same geographical area. Pollution would then be reduced by the same amount as under the NSPS approach, but some of the disincentive to introduce new sources would be removed. In some cases, securing emission reductions from existing sources (which are often largely uncontrolled) would be less costly than the higher removal efficiencies called for under existing new source performance standards.

An additional benefit of using the offset approach in the NSPS might be improved productivity secured by use of more sophisticated technology in new plants and equipment that allow each worker to produce more than before. Thus environmental quality might be maintained without loss of productivity.

Another and different kind of economic incentive might increase the accuracy of the information that polluters provide to regulatory agencies in advance of standard setting. When EPA is considering imposition of a standard, it needs to know the cost to a company of meeting that standard. Under current practice, the company has an incentive to exaggerate the cost to make the regulation appear unjustifiable (some evidence of the accuracy of both private and government estimates of compliance costs is discussed later in this chapter). If in fact companies are exaggerating compliance costs, they are depriving regulatory agencies of potentially the most reliable cost data, that from the affected firms.

What can be done to prevent exaggeration of expected compliance costs? One possibility is to link penalties for violations to compliance cost estimates—that is, to make the penalty for noncompliance with an established regulation dependent upon the previous

estimate of the costs of compliance. Then a company would be free to claim that compliance with a proposed regulation would be unjustifiably costly, but future penalties for noncompliance would be greater than if the firm had provided a more realistic estimate of costs.

Linking noncompliance penalties to compliance cost estimates might make it possible to improve *ex ante* analysis (analysis prior to issuance of regulations) of the impacts of regulation by providing more accurate information than is now available. For such a system to have legal sanction, the affected firms would have to make their cost estimates official, increasing the resources needed to estimate costs, resources otherwise available for production. The usefulness of such an approach, then, depends upon the value of improved estimates of compliance costs compared to the additional effort entailed by such estimates.

Still another means of obtaining more accurate information on the costs of complying with environmental regulation is suggested by recent action taken by the Securities and Exchange Commission. The SEC ordered two very large firms—U.S. Steel and Occidental Petroleum—to disclose to their stockholders potential liabilities arising from pollution control costs or other environmental activities.[11] The SEC found that between 1973 and 1977, U.S. Steel had not adequately disclosed to its stockholders the costs associated with coming expenditures on air and water pollution control, thus making its financial condition appear better than was actually the case. Occidental, the SEC found, had failed to inform stockholders of possible liabilities arising from waste disposal practices of its subsidiary, Hooker Chemical, at Love Canal.

If firms were required to incorporate in reports to the SEC and to report to stockholders the same estimates of pollution control compliance costs that they provide to regulatory agencies, exaggerated estimates to agencies might become less common. Presumably, firms would not want to alarm stockholders with the prospect of large liabilities for pollution control. Neither would they want regulatory agencies to think that potential new regulations were costless.

COST-BENEFIT ANALYSIS AND THE COURTS

Unsettled issues in the setting of regulations include the extent to which regulatory agencies must demonstrate the benefits of their proposed actions and the relationship that these benefits must bear to the costs of regulation. The Supreme Court considered in part the first of these issues in 1980.

In July 1980, the Supreme Court handed down a decision in *Industrial Union Department, AFL–CIO* v. *American Petroleum Institute et al.*[12] The Court upheld in part a 1978 ruling by the U.S. Court of Appeals for the Fifth Circuit.[13] The Fifth Circuit had ruled

in favor of the American Petroleum Institute (API) that the Occupational Safety and Health Administration (OSHA) could not tighten the standard limiting worker exposure to benzene from 10 parts per million to 1 ppm without first conducting a cost-benefit analysis of the proposed change. OSHA had argued that some of the costs and benefits of the proposed change were unquantifiable and that it was prohibited by law from considering the costs of regulation except to determine that industry was capable of bearing them.

By a 5–4 majority, the Supreme Court upheld the circuit court's invalidation of the benzene standard on grounds that OSHA had failed to produce evidence that a "significant risk of harm exists" at the old standard that would justify the proposed revision. Rather, OSHA had merely asserted that the change would afford workers more protection.

The Court chose not to rule on whether benefits had to be completely and precisely quantified or had to bear some reasonable relationship to costs.[14]

EXPENDITURES ON ENVIRONMENTAL QUALITY

Each year the Council has estimated current and future expenditures for pollution abatement and other measures to protect or enhance environmental quality. These estimates serve several purposes. They can be used to help determine the macroeconomic effects of federal environmental regulation,[15] and they can be compared with broad-scale estimates of the benefits associated with environmental regulations.[16] Because of their high level of aggregation, however, the CEQ estimates cannot be used to evaluate the benefits and costs of specific standards or provisions of the Clean Air Act, the Clean Water Act, or similar legislation. Such evaluations are clearly of great importance when changes are considered in specific provisions of environmental statutes.

As Table 10–1 indicates, CEQ estimates that the nation spent $36.9 billion in 1979 to comply with federal environmental protection regulations. (Spending necessitated by federal regulation is termed "incremental" by CEQ). The $36.9 billion amounted to approximately 1.5 percent of GNP in 1979, 0.2 percent higher than in past years. The increase was caused by spending on new regulations, the effects of which are only now beginning to be felt. The Toxic Substances Control Act and the Surface Mining Control and Reclamation Act are the most prominent examples.

Air and water pollution controls (mandated by the Clean Air Act and Clean Water Act) accounted for 95 percent of incremental expenditures, $35.0 billion. Of this amount, air pollution control accounted for $22.3 billion—$1.5 billion of which was spent by federal, state, and local governments for the control of air pollution at hospitals, military installations, incinerators, and other municipal disposal

Table 10–1

Estimated Incremental Pollution Abatement Expenditures,[a] 1979–88

(billions of 1979 dollars)

Program	1979			1988			Cumulative (1979–88)		
	Operation and maintenance	Annual capital costs[b]	Total annual costs	Operation and maintenance	Annual capital costs[b]	Total annual costs	Operation and maintenance	Capital costs[b]	Total costs
Air pollution									
Public	1.2	.3	1.5	2.0	.5	2.5	15.8	3.7	19.5
Private									
Mobile	3.2	4.9	8.1	3.7	11.0	14.7	32.1	83.7	115.8
Industrial	2.0	2.3	4.3	3.0	4.1	7.1	25.8	33.0	58.8
Electric utilities	5.5	2.9	8.4	7.6	5.7	13.3	62.3	42.7	105.0
Subtotal	11.9	10.4	22.3	16.3	21.3	37.6	136.0	163.1	299.1
Water Pollution									
Public	1.7	4.3	6.0	3.3	10.0	13.3	25.1	59.2	84.3
Private									
Industrial	3.4	2.6	6.0	5.4	4.5	9.9	42.0	34.0	76.0
Electric utilities	.3	.4	.7	.3	.9	1.2	2.9	6.5	9.4
Subtotal	5.4	7.3	12.7	9.0	15.4	24.4	70.0	99.7	169.7
Solid waste									
Public	<.05	<.05	<.05	.4	.3	.7	2.6	2.0	4.6
Private	<.05	<.05	<.05	.9	.7	1.6	6.4	4.4	10.8
Subtotal	<.05	<.05	<.05	1.3	1.0	2.3	9.0	6.4	15.4
Toxic substances	.1	.2	.3	.5	.6	1.1	3.6	4.6	8.2
Drinking water	<.05	<.05	<.05	.1	.3	.4	1.3	1.4	2.7
Noise	<.05	.1	.1	.6	1.0	1.6	2.6	4.3	6.9
Pesticides	.1	<.05	.1	.1	<.05	.1	1.2	<.05	1.2
Land reclamation	.3	1.1	1.4	.3	1.2	1.5	3.8	11.5	15.3
Total	17.8	19.1	36.9	28.2	40.8	69.0	227.5	291.0	518.5

[a] Incremental costs are those made in response to federal legislation beyond those that would have been made in the absence of that legislation.

[b] Interest and depreciation.

sites. The control of air pollution from automobiles, trucks, buses, and motorcycles cost $8.1 billion. Electric utilities spent $8.4 billion for air pollution control; all other industrial sources spent $4.3 billion. The $22.3 billion for air pollution control was divided rather evenly between operation and maintenance expenses and annual capital costs (which include interest and depreciation).

Of the $12.7 billion in incremental water pollution control expenditures in 1979, municipalities spent $6.0 billion for waste water treatment. Industrial sources other than electric utilities spent another $6.0 billion for water pollution control; utilities accounted for the remaining $0.7 billion.

Approximately $1.9 billion spent in 1979 was expended on the reclamation of land following strip mining (under the Surface Mining Control and Reclamation Act), the control of toxic substances (under the Toxic Substances Control Act), the protection of drinking water (under the Safe Drinking Water Act), the elimination or attenuation of noise (under the Noise Control Act), and the control of pesticides (under the Federal Insecticide, Fungicide, and Rodenticide Act). Land reclamation accounted for $1.4 billion of the $1.9 billion devoted to expenditures on other than air and water pollution control.

CEQ estimates that by 1988, expenditures necessitated by federal environmental measures will grow to $69.0 billion (in 1979 dollars), a real rate of growth of about 7.2 percent per year. Air and water pollution control will still account for the greatest share of incremental spending in 1988—$62.0 billion—but spending for other programs will grow to 10 percent of the total. By then, $2.3 billion will be required annually to control the disposal of hazardous and other wastes in compliance with the Resource Conservation and Recovery Act.

During the 10 years 1979–88, spending in response to the federal environmental quality regulations considered here is expected to amount to $518.5 billion. Of this cumulative incremental spending, air pollution control will total nearly $300 billion (58 percent), water quality programs will require about $170 billion (33 percent), and all other programs together will account for the remaining $50 billion. Of this $50 billion, $15.3 billion will be devoted to land reclamation and another $15.4 billion to control of the disposal of hazardous wastes. The control of hazardous substances will require $8.2 billion, and noise control measures will cost $6.9 billion.

In addition to estimating spending in response to federal environmental legislation, CEQ has estimated total spending on pollution abatement and other environmental measures, including expenditures made in response to state or local environmental controls (which are sometimes quite stringent) or voluntary expenditures made for reasons of principle or private profitability. These estimates obviously require some assumptions about what industry, households, and government units would have spent on pollution control in the

absence of federal regulations. These baseline expenditures, as they are called, are determined by examining environmental expenditures in the mid- to late 1960s prior to establishment of present federal environmental regulations and then extrapolating trends to the present. Because extrapolation of this kind is a particularly difficult task, estimates of total expenditures should be viewed as only broadly suggestive.

As shown in Table 10–2, spending on all environmental programs, either voluntary or in response to federal, state, or local statutes, is estimated at $735.0 billion between 1979 and 1988. Air pollution will account for $338.8 billion, water pollution for $250.0 billion, and solid waste disposal for $100.9 billion. The share of solid wastes in total expenditures is much greater than its share in incremental spending because much of the spending on solid wastes is either voluntary or in response to state or local regulations. All other programs are expected to account for $45.3 billion of total expenditures between 1979 and 1988.

There is a great deal of uncertainty in these estimates. Although they are presented as point estimates (that is, as single numbers), they might better be presented as ranges because of the uncertainties involved in determining them. It should also be noted that these estimates reflect anticipated costs of compliance for environmental regulations in effect as of mid-1980. This year's totals reflect new methods for estimating compliance costs for several programs. Differences in methods explain some differences between this year's estimates and those in previous Annual Reports.

ACCURACY OF POLLUTION CONTROL COST ESTIMATES

A study conducted for EPA in 1980 attempted to assess the accuracy of some of the estimated costs of complying with federal environmental law.[17] Because the study did not consider all industries and regulations or the cost of regulation to the public, its findings cannot easily be generalized to the aggregate estimates of federal environmental regulation compliance costs that CEQ makes. Nevertheless, the report gives some indication of the precision of compliance cost estimates.

The study compared *ex ante* estimates of pollution control costs for several industries made when a regulation was issued with actual expenditures that were eventually made. It examined estimates prepared by EPA and its contractors and estimates prepared by industry. Estimates were then adjusted for the fact that not all firms actually complied with the regulations; "compliance-adjusted" estimates were compared with actual expenditures.

The study examined estimates of compliance costs of best practicable technology (BPT) effluent guidelines for the iron and steel, pulp and paper, petroleum refining, and steam electric utility industries

Table 10–2

Estimated Total Pollution Abatement Expenditures, 1979–88

(billions of 1979 dollars)

Program	1979			1988			Cumulative (1979–88)		
	Operation and maintenance	Annual capital costs	Total annual costs	Operation and maintenance	Annual capital Costs[a]	Total annual costs	Operation and maintenance	Capital costs	Total costs
Air pollution									
Public	1.7	.4	2.1	2.8	.7	3.5	22.5	5.3	27.8
Private									
Mobile	3.2	4.9	8.1	3.7	11.0	14.7	32.1	83.7	115.8
Industrial	2.5	2.9	5.4	3.9	5.1	9.0	32.5	41.5	74.0
Electric utilities	6.3	3.5	9.8	8.5	6.5	15.0	71.1	50.1	121.2
Subtotal	13.7	11.7	25.4	18.9	23.3	42.2	158.2	180.6	338.8
Water pollution									
Public	3.7	8.2	11.9	5.4	14.2	19.6	45.4	99.7	145.1
Private									
Industrial	4.4	3.2	7.6	6.4	5.1	11.5	52.4	41.1	93.5
Electric utilities	.4	.5	.9	.4	1.1	1.5	3.6	7.8	11.4
Subtotal	8.5	11.9	20.4	12.2	20.4	32.6	101.4	148.6	250.0
Solid waste									
Public	1.7	.3	2.0	2.5	.6	3.1	21.8	5.3	27.1
Private	4.5	.7	5.2	7.5	1.6	9.1	61.3	12.5	73.8
Subtotal	6.2	1.0	7.2	10.0	2.2	12.2	83.1	17.8	100.9
Toxic substances	.1	.2	.3	.5	.6	1.1	3.6	4.6	8.2
Drinking water	.3	.4	.7	.5	.8	1.3	5.3	5.2	10.5
Noise	<.05	.1	.1	.6	1.0	1.6	2.6	4.3	6.9
Pesticides	.1	<.05	.1	.1	<.05	.1	1.6	.1	1.7
Land reclamation	.4	1.3	1.7	.4	1.4	1.8	4.5	13.5	18.0
Total	29.3	26.6	55.9	43.2	49.7	92.9	360.3	374.7	735.0

[a] Interest and depreciation.

issued under the Clean Water Act, Clean Air Act requirements for scrubbers in the electric utility industry, and vehicle emissions standards for new light-duty automobiles required by the Clean Air Act.

The study report reveals that compliance cost estimates prepared by EPA or its contractors were lower than industry estimates for five of the six regulations examined; only the pulp and paper industry's estimate of the costs of meeting BPT effluent guidelines was below that of EPA. However, EPA estimates were not consistently high or low compared to actual costs. In two cases EPA appeared to underestimate costs, in three cases it appeared to overestimate costs, and for vehicle emissions standards, the estimates appeared to be too high in two model years and too low in a third.

Industry also overestimated compliance costs in some cases and underestimated in others. For the BPT guidelines in the iron and steel industry, the apparent overestimate was substantial, ranging from 2.5 to 3.5 times the actual cost. On the other hand, industry estimates of the cost of scrubbers to electric utilities and the cost of the BPT effluent guidelines in the pulp and paper industry were less than actual expenditures. Industry compliance cost estimates for vehicle emissions standards were both higher and lower than actual increases in sale prices resulting from the regulations.

Overall, the report shows that EPA appears to be slightly better at estimating compliance costs than are the affected industries. As Table 10–3 indicates, EPA's ratio of estimated-to-actual expenditures is more often nearer 1.0 than the ratio for corresponding industry estimates (a ratio of 1.0 means that actual expenditures were forecast exactly). In BPT guidelines for electric utilities and model year 1976 vehicle emissions costs, the EPA estimate was within 10 percent of eventual actual expenditures. The electric utility industry's estimate of scrubber costs was also within 10 percent of actual expenditures.

A first attempt to compare predicted and actual compliance costs, this study is a useful one. But it must be interpreted carefully. First, it is difficult to determine actual (*ex post*) expenditures incurred to comply with a regulation. The study used data reported by the Bureau of Economic Analysis, McGraw-Hill, the Bureau of Labor Statistics, and industry trade associations. Although these data are the best available on actual spending for pollution control, they do not differentiate between spending undertaken to comply with specific federal regulations and that undertaken because of state or local regulations or private profitability. Further, it is difficult to isolate pollution control spending from that for modern equipment and streamlined production processes, for example.

In addition, as Chapter 4, Air Quality, points out, compliance data vary in quality. Thus it is not clear how accurate estimates of pollution control compliance costs are once they have been adjusted for industry compliance ratios. Such an adjustment will not affect the

Table 10–3

Ratio of Estimated to Actual Pollution Control Expenditures in Selected Industries

Industry and regulation	Ratio
Electric utility scrubber	
EPA	0.74
Industry	0.91
Utilities (BPT guidelines)	
EPA	0.89–0.91
Industry	1.36–1.40
Pulp and paper (BPT guidelines) [a]	
EPA	1.27–1.49
Industry	0.75
Iron and steel (BPT guidelines)	
EPA	1.32–1.79
Industry	2.56–3.47
Petroleum refining (BPT guidelines)	
EPA	1.87–2.50
Industry	1.91–2.62
Automobile emissions standards [b]	
1974 model year	
EPA	1.32–1.45
Industry	0.72–1.74
1976 model year	
EPA	0.93–1.02
Industry	0.51–2.31

BPT = Best practicable technology.
[a] EPA estimate, 1974–77; industry estimate, 1972–77.
[b] Ratio of estimated to actual sale price increase as calculated by the Bureau of Labor Statistics.

Source: Putnam, Hayes & Bartlett, Inc., "Comparisons of Estimated and Actual Pollution Control Cost for Selected Industries," prepared for the U.S. Environmental Protection Agency, February 1980.

accuracy of EPA estimates compared with those of industry (because both are adjusted in the same way). But the tendency of either party to over- or under-estimate actual costs is less apparent.

REFERENCES

1. See Council of Economic Advisors, *Economic Report of the President* (Washington, D.C.: U.S. Government Printing Office, 1980), p. 85.
2. See Council on Environmental Quality, *Environmental Quality—1979: The Tenth Annual Report of the Council on Environmental Quality* (Washington, D.C.: U.S. Government Printing Office, 1980), pp. 647–48.
3. For a comprehensive analysis of the benefits of air and water pollution control, see A.M. Freeman, *The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates* (Springfield, Va.: National Technical Information Service, 1980).
4. Edward Denison, "Effects of Selected Changes in the Institutional and Human Environment upon Output per Unit Input," *Survey of Current Business* 58(1):21–44 (1978).

5. Edward Denison, "Pollution Abatement Programs: Estimates of Their Effect upon Output per Unit Input," *Survey of Current Business* 59(8):58–59 (1979).
6. See Gregory Christainsen and Robert Haveman, University of Wisconsin-Madison, "Environmental Policy and the Slowdown in U.S. Productivity Growth: An Assessment of the Evidence," prepared for the Environmental Directorate, Organization for Economic Cooperation and Development, September 1979; Gregory Christainsen and Robert Haveman, University of Wisconsin-Madison, "Environmental Regulation and Its Impact on the Economy," prepared for Resources for the Future, April 1980.
7. Gregory Christainsen and Robert Haveman, "Environmental Regulation and Its Impact on the Economy," *supra* note 6, at 38.
8. See, for example, Council on Environmental Quality, *supra* note 2, at 668–80.
9. For an explanation of these policies, see *id.* pp. 678–80.
10. For one such view, see ICF, Inc., "Effects of Alternative New Source Performance Standards for New Coal-Fired Electric Utility Boilers on the Coal Market and on Utility Capacity Expansion Plans," submitted to the U.S. Environmental Protection Agency and the U.S. Department of Energy, September 1978, p. 11.
11. See Agis Salpukas, "U.S. Steel Disclosure Criticized," *Wall Street Journal,* September 28, 1979; John F. Berry, "Occidental Told to List Liabilities," *Washington Post,* July 3, 1980, p. E1.
12. *Industrial Union Department, AFL-CIO* v. *American Petroleum Institute et al.,* No. 78–911, and *Ray Marshall, Secretary of Labor* v. *American Petroleum Institute et al.,* No. 78–1036 (S. Ct. July 2, 1980).
13. *American Petroleum Institute* v. *Occupational Safety and Health Administration,* 581 F.2d 493 (5th Cir. 1978).
14. See *Industrial Union Department, AFL-CIO, supra* note 12.
15. For example, see Data Resources, Inc., "The Macroeconomic Impact of Federal Pollution Control Programs: 1978 Assessment" (Springfield, Va.: National Technical Information Service, 1979).
16. See A.M. Freeman, *supra* note 3.
17. Putnam, Hayes & Bartlett, Inc., "Comparisons of Estimated and Actual Pollution Control Cost for Selected Industries," prepared for the U.S. Environmental Protection Agency, February 1980.

APPENDIX A

PUBLIC OPINION ON ENVIRONMENTAL ISSUES

Resources for the Future, a nonprofit research organization in Washington, D.C., conducted a national public opinion survey (the RFF survey) in 1980 for the Council on Environmental Quality.* The study was designed and the data were analyzed and interpreted by Robert Cameron Mitchell, a sociologist and Senior Fellow at Resources for the Future. The sample design, field work, and initial data preparation were performed by Roper and Cantril, a joint venture of the Roper Organization and Cantril Research, Inc.

Roper and Cantril interviewed 1,289 adults in person between January 26 and February 9, 1980. Between March 24 and April 5, 287 more people were interviewed, increasing the final sample to 1,576. An interview took approximately one-half hour. In order to maximize the number of questions asked, the sample was divided into two equivalent parts, and some questions were asked of only one or the other subgroup.

The survey sought to sample the civilian population 18 years of age and older. The sampling plan was a multistage probability sample —that is, it employed widely used statistical methods to select a random sample of the population. Once an eligible person was identified, as many as four attempts were made to arrange an interview. Seventy-three percent of the individuals selected were ultimately interviewed.

All sample surveys are subject to sampling error. The size of the possible sampling error varies according to the size of the sample (the larger the sample, the smaller the possible error) and the percentage responding one or another to a particular question (percentages near 50 have larger possible errors than those near 10 or 90). For the entire sample of 1,576 respondents, the chances are 95 out of 100 that the results on a particular question are within 2 to 3 percentage points of the results that would have been obtained from a very large sample selected and interviewed in a similar manner. Some additional small changes might have resulted from the responses of individuals who could not be interviewed.

* The survey was also sponsored by the U.S. Department of Agriculture, the U.S. Department of Energy, and the Environmental Protection Agency. It is reprinted here from *Public Opinion on Environmental Issues: Results of a National Public Opinion Survey* (Washington, D.C.: U.S. Government Printing Office, 1980).

Public concern played a major role in the sudden emergence of environmental problems as a leading item on the national agenda at the beginning of the 1970s. This concern, which showed up in the polls in the late 1960s, manifested itself dramatically in April 1970 when hundreds of thousands participated in Earth Day events all over the country. As "environment" became a familiar word, some people believed that public enthusiasm was a fad that would die as soon as the cost of pollution control programs became apparent. Instead, strong public support for pollution control has endured.

At the close of the first environmental decade—when anxiety about taxes, regulation, energy supply, and the state of the economy is high—it seems appropriate to take stock of the public's views on environmental issues, as measured by the polls. This study reviews the findings of several polls taken in the past 15 years and reports on a special comprehensive national environmental survey conducted by Resources for the Future for the Council on Environmental Quality in January–February 1980. The RFF poll repeated some key questions of earlier polls in order to assess trends in public opinion about environmental protection. It also included questions on newer environmental issues in order to compile benchmark data.

To make the RFF survey as realistic a test of public opinion as possible, the poll included a number of questions with difficult tradeoffs. Moreover, it began with questions that required respondents to compare the environment with a wide range of other concerns. Because of this unusual polling technique and because the poll was conducted at a time of exceptional concern about both economic and international issues (Afghanistan and Iran were much in the news), the RFF survey may be regarded as an especially strict test of support for environmental issues.

The overall results of the RFF survey—and those of numerous other polls conducted in the past decade—demonstrate the fact that environmental protection enjoys continued strong backing. The intensity of public concern about environmental problems has lessened somewhat since its peak on Earth Day 1970. Other problems, in particular, national defense and inflation, are more urgent now. But the answers to a broad range of probing questions show abiding public support for national efforts to protect environmental quality. Environmental issues seem to have become an enduring social concern, much like health care, education, and other basic issues.

Judged by their answers in several surveys, most of the population is willing to pay for environmental protection. In 1980, for example, in answer to the University of Chicago's National Opinion Research Center's oft-repeated question whether spending on domestic programs is too much, too little, or about right, 48 percent of the respondents said that spending on environmental problems was "too little"; only 15 percent answered that the amount was "too much." Despite the very large sums spent in the 1970s on environmental protection and despite public preoccupation with economic and energy concerns, a plurality of respondents to the 1980 RFF poll thought environmental protection was too important to consider the cost. Presented with three alternatives, 42 percent chose the one which read: "Protecting the environment is *so important* that requirements and standards cannot be too high, and continuing improvement must be made *regardless* of cost" (emphasis in the original).

When asked for an opinion on the statement, "An endangered species must be protected, even at the expense of commercial activity," 73 percent of the respondents in the RFF poll agreed; only 20 percent disagreed. Given three options on a tradeoff between growth and environment, only one in five respondents chose the statement, "We must relax environmental standards in order to achieve economic growth."

Although most people appear unwilling to sacrifice environmental standards in order to achieve economic growth, the prospect of inadequate

energy supplies is another matter. In the RFF poll, 73 percent of the respondents were concerned "a great deal" about fuel shortages, and 8 out of 10 said that they were personally affected "a great deal" or "a fair amount" by energy shortages. In various polls asking energy-environment tradeoff questions in the late 1970s, a plurality chose energy. For example, in September 1979, an NBC News poll found that 47 percent of respondents considered "building a needed refinery or pipeline" more important than "protecting the environment"; 40 percent said that protecting the environment was more important. Yet in answer to questions about future energy sources, the environmentally benign energy choices such as solar energy and conservation came out on top in all the polls, including the RFF survey.

Asked about the seriousness of the air pollution problem in this country, 9 in 10 respondents to the 1980 RFF survey answered that it is "somewhat" or "very serious"; only 8 percent felt that it is not a serious problem. One-half the respondents believed air pollution to be a serious problem in their own communities. Similarly, 39 percent were worried "a great deal" and 44 percent "a fair amount" about water pollution. Forty-six percent were very worried about toxic chemicals in the environment, and 64 percent of the respondents expressed deep concern over the disposal of hazardous wastes.

Particularly striking in the RFF survey is evidence that environmentalism retains its widespread appeal. Seventy-three percent of the respondents said that the term "environmentalist" applies to them "definitely" or "somewhat." The percentage of people who regard themselves as "active participants" in the environmental movement has shrunk from 13 percent in 1978 to 7 percent in 1980. Yet the proportion expressing sympathy with the environmental movement remains the same, 62 percent. Only 4 percent are unsympathetic. Moreover, support for the environmental movement is not limited to the affluent, the well educated, or the young; it cuts across most demographic categories.

POLLING ON ENVIRONMENTAL ISSUES

A sign of the relatively inconsequential role of environmental issues in national affairs before the 1970s is the conspicuous absence of public polls on the subject. Some private polling about pollution was commissioned by industry, however; a detailed survey conducted by Louis Harris in 1964 found that "rising public interest in the problems of air and water pollution was the most frequently recurring theme."

The number of public polls on environmental issues gradually increased until the early 1970s, when they became a regular occurrence. But despite the large number of questions on environmental, resource, and energy matters, relatively few were repeated regularly, so that trend analysis was difficult. Nevertheless—thanks to Harris, Gallup, Roper, the Opinion Research Corporation, and others—there is now a large body of data on public opinion about a wide variety of environmental issues, and there are some basic data on trends.

Because some regard the environment as the ultimate "motherhood" issue, they are inclined to discount poll results; the assumption is that people automatically give the environment lip service even when they harbor negative views about pollution control. If the polls simply asked for approval or disapproval of environmental protection, they would deserve such criticism. In practice, such questions are rarely asked. The polls have become more sophisticated over the years. For example, increasingly often tradeoff questions are asked. They require individuals to make choices between environmental protection and higher prices, higher taxes, lower economic growth, and higher unemployment. By and large, polls using these questions indicate

that people are willing to pay for environmental quality. The 1980 RFF findings confirm these results.

THE ENVIRONMENT IN THE CONTEXT OF OTHER ISSUES

In 1965, George Gallup asked one of the first questions about environmental issues in a public poll. His interviewers presented a list of 10 national problems and asked which 3 the government should devote most of its attention to in the next year or so. As shown in Table 1, "reducing pollution of air and water" was chosen by 17 percent in 1965, placing it ninth, just after "improving highway safety" and a few percentage points ahead of "beautifying America." When Gallup repeated the question in 1970 after Earth Day, the respondents choosing pollution tripled, and it was in second place. Since 1970, the government has in fact devoted a great deal of attention to environmental problems, and it appears that the state of the environment is no longer viewed as a crisis. When the question was asked in the 1980 RFF survey, unemployment had risen to second place as an immediate government priority, and air and water pollution had dropped to sixth place.

Responses to another question in the 1980 survey also suggest that other concerns have supplanted environmental protection in terms of urgency. Of 12 broad national goals presented for selection of the *most* desirable, 2 goals each received one-quarter of the votes: "Making sure that this country has strong defense forces" and "Fighting rising prices." None of the others, which covered a broad spectrum from protecting nature to fighting crime, was "most important" to more than 11 percent of the respondents.

Although environmental protection is no longer viewed as a crisis issue, support for national environmental protection efforts remains strong. An-

Table 1

Ranking of National Problems

Q.1. First, I would like to ask you which *three* of these national problems you would like to see the government devote most of its attention to in the next year or two?

Problem	1965 April [1]	1970 April	1980 Jan.–Feb.[2]	Change 1965–1980
Reducing the amount of crime	41%	56%	61%	+20
Reducing unemployment	35	25	48	+13
Conquering "killer" diseases	37	29	41	+4
Improving public education	45	31	35	−10
Helping people in poor areas	32	30	29	−3
Reducing pollution of air and water	17	53	24	+7
Improving housing and run-down neighborhoods	21	27	20	−1
Reducing racial discrimination	29	25	13	−16
Improving highway safety	18	13	7	−11
Beautifying America	3	5	5	+2
N =	c. 1,500	c. 1,500	840	

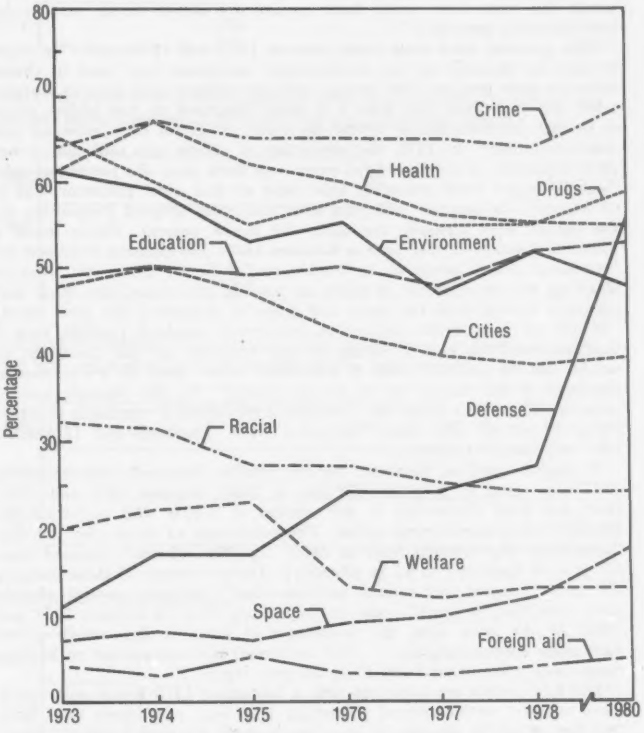
[1] Data for 1965 and 1970 are from Gallup surveys. The Gallup 1970 survey was taken immediately after the first Earth Day.

[2] RFF survey. The number of cases is smaller than the total (N = 1,576) because the question was asked of only a subsample.

nually from 1973 to 1978 and again in 1980, the National Opinion Research Center asked a national sample whether "we're spending too much money, too little money, or about the right amount" on each of 11 social problems. In 1980, 48 percent said that the country is spending "too little" on the environment, and 31 percent said that the amount was "about right." Only 15 percent believed that we are spending "too much," up from 10 percent in 1978. Percentages of respondents who chose "too little" are shown in Figure 1. As more action has been taken to control pollution over the years, the number of people who said that "too little" is being spent

Figure 1

Percentage Saying That We're Spending "Too Little" on Eleven Problems, 1973-1980[1]



[1]National Opinion Research Center, University of Chicago, General Social Survey, personal interview survey, with an average sample size of approximately 1,500. The 1980 interviews were conducted in February-April with N = 1,468.

"We are faced with many problems in this country, none of which can be solved easily or inexpensively. I'm going to name some of these problems, and for each one I'd like you to tell me whether you think we're spending too much money on it, too little money, or about the right amount. . . ."

on environmental problems has dropped somewhat from its 1973 high of 60 percent. Nonetheless, the environment remains high on the list of social problems.

THE ENVIRONMENT AND ECONOMIC TRADEOFFS

Asking individuals to choose among rival alternatives is an especially revealing way to determine public preferences. Such tradeoffs often arise in discussions of environmental policy because controls may increase the cost of business and government activities, because maintenance of environmental quality is sometimes viewed as inconsistent with a rapidly growing economy, and because some of the proposed energy supply options involve environmental costs.

In recent years several polls included economic tradeoff questions in an effort to discover whether people believe that environmental protection is worth the costs. The results have consistently shown strong support for environmental programs.

One question, used three times between 1975 and 1978, was: "In order to pay for cleaning up the environment, companies may have to charge more for their products and services, and government may have to increase taxes. Do you think that *now* it is more important to pay higher prices to protect the environment, or to pay lower prices but have more air and water pollution?" In 1975, the percentage of people who said that it was more important to pay the higher prices was three times the percentage who "wanted to pay lower prices but have more air and water pollution" (58 to 17 percent). In summer 1978, just after California adopted Proposition 13, the figures were virtually the same—62 to 18 percent. Harris asked a different question on this topic in October 1979. His question described the "continual debate going on in Washington" between those who want to clean up the environment as much as possible and those who think that pollution control costs too much and must be restrained. He then asked: "Would you enforce the toughest environmental standards possible, even if they increased the cost of things to both business and the consumer, or would you be satisfied with a somewhat lower level of environmental standards if this turned out to be less costly?" To this strongly worded question, 45 percent chose the "toughest environmental standards possible" versus 36 percent who chose "somewhat lower" standards and 12 percent who said that "it depends."

A general question, first used by the Opinion Research Corporation in 1977, was asked by RFF in 1978 and in 1980. Between 1977 and 1980, there was some diminution in the number of people who supported the strongest pro-environmental option. The percentage of those who felt that "continuing improvement must be made *regardless* of cost" declined from 55 (a clear majority) to 42 (a plurality). The percentage of those favoring the most stringent cost-control position—that "pollution control already costs more than its worth"—also declined, from 19 to 13 between 1977 and 1980. At the same time, the percentage of those in the middle ("We have made enough progress . . . that we should now concentrate on holding down costs") increased from 20 to 34 (see Figure 2).

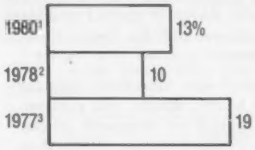
The RFF results are consistent with a September 1979 Roper poll, which asked whether environmental protection laws and regulations have gone "too far, or not far enough, or have struck about the right balance." Sixty-five percent of the respondents in the Roper survey said that the balance was right (36 percent) or that environmental protection has not gone far enough (29 percent). Only 24 percent said that environmental laws and regulations have gone too far. Roper's polls have shown that the percentages of those approving the balance or wanting more protection have remained the same from 1973 to 1979. The percentage of those who

Figure 2

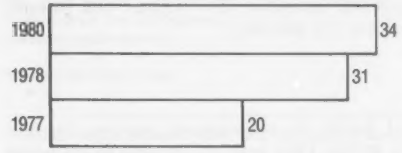
Views about Pollution Control, 1979-80

Q.34 I am going to read you three points of view regarding pollution control. Please tell me which one best represents your opinion.

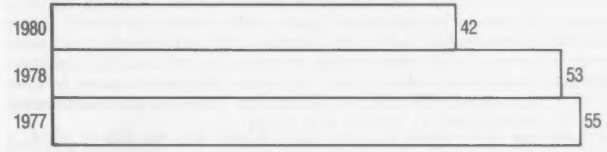
Pollution control requirements and standards have gone too far; it already costs more that it is worth.



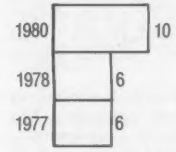
We have made enough progress on cleaning up the environment that we should now conentrate on holding down costs rather than requiring stricter controls.



Protecting the environment is so important that requirements and standards cannot be too high, and continuing improvements must be made regardless of cost.



Don't know, no answer, depends.



[1]RFF survey, N = 1,576.
[2]Resources for the Future telephone survey, July-August 1978, N = 1,076.
[3]Opinion Research Corporation telephone survey, January 1977, N = 1,003.

believed that the government has gone too far has gradually increased from 13 in 1973 to 24 in 1979, with the percentage of "don't know" declining proportionately.

The continuing reluctance of most people to weaken environmental control programs in the name of economy is shown in recent polls which asked about types of goverment spending. Although 69 percent of the respondents in a January 1979 Harris poll favored "a major cutback in federal government spending," 57 percent in the same poll *opposed* "a major cutback in federal government spending if that meant cutting back in spending for environmental protection." A Gallup poll for *Newsweek* in February 1980 found that 87 percent of the respondents wanted to maintain or increase government spending for water pollution control programs. Roger Seasonwein Associates conducted an extensive poll for Union Carbide in fall 1979 with similar findings. It concluded:

> Most Americans think that it is the consumer who ultimately pays for most government regulations, and they see health, safety, and environmental regulations as having the greatest impact on consumer prices. Yet many apparently believe the price well worth paying since they say they want precisely these types of regulations made more, rather than less strict.

The Seasonwein poll also asked about economic and environmental impact statements. Many more people favored than opposed their use, but environmental impact statements received somewhat more support (66 percent) than economic impact statements (59 percent).

GROWTH

One of the consequences of the rise of environmental awareness has been a reconsideration of economic growth. Prior to the 1970s, growth was widely regarded as the driving force behind increased prosperity and an ever increasing standard of living. Growth is still regarded very favorably by most people, but there is far wider recognition that rapid growth may entail environmental costs.

The polls now indicate that, forced to make a choice, a strong majority of people will choose environmental quality over growth. A Harris survey for the Soil Conservation Service in October 1979 gave people the choice between a country which believes that economic growth is more important than protecting the environment and one where the environment is more important than growth. Two to one the sample preferred the environment (52 to 24 percent) and 21 percent was neutral.

In 1978 and 1979 Harris asked people whether they favored or opposed new industrial growth in their communities under three different conditions —with no explicit conditions stated, with the air "a little dirtier," and with the air "a lot dirtier." When no conditions were stated, more people than not favored new industrial growth (59 to 36 percent). When some environmental effects were introduced—when growth "made the air a little dirtier" —support dropped to 49 percent, and 43 percent opposed growth. If the air would be "a lot dirtier," only 15 percent favored new industrial growth in their communities, with 80 percent opposed.

The RFF survey asked a general question which attempted to elicit views on the relationship of economic growth to environmental protection. The question had been asked in 1978 by the Opinion Research Corporation— which of three views people most agreed with: we should slow growth to protect the environment, we should relax environmental standards to facilitate growth, or we can achieve both at the same time. In 1980 a much smaller percentage of respondents said that growth should be sacrificed to protect the environment (27 percent in 1980 versus 58 percent in

1978). However, a larger percentage (39 versus 18) said that *both goals* can be achieved. There has been no increase in the percentage of people who believe that environmental standards should be relaxed in order to achieve growth; only one out of five people in each survey believed that they should. Table 2 shows the responses to this question.

Table 2

Views about Economic Growth and Environmental Protection

I am going to read you three statements about environmental protection and economic growth. Please listen carefully and tell me which statement you agree with the most.

Statement	1978 [1]	1980 [2]
We must relax environmental standards in order to achieve economic growth.	20%	20%
We can achieve our current goals of environmental protection and economic growth at the same time.	18	39
We must accept a slower rate of economic growth in order to protect the environment.	58	27
Depends (volunteered).	4	4
No opinion, don't know.		9
N =	1,002	1,576

[1] *ORC Public Opinion Index*, Vol. 36, Nos. 17 and 18, September 1978. Interviewing took place August 24–30, 1978.
[2] RFF survey.

Past surveys have shown strong sentiment for protecting wilderness areas and for preserving trees in their natural state in the National Forests rather than increasing the forests' yield of timber. The RFF survey in 1980 asked whether marsh and swamp areas should be developed or preserved in their natural state. Noting that many of these areas have been drained for residential, industrial, and agricultural use, the survey said:

> Some people say we should drain more of these areas because land for development is becoming harder to find. Other people say that these marsh and swamp areas should be kept as they are because they help maintain nature's balance by providing breeding areas for fish and feeding places for ducks among other things. Who do you agree with most—those who feel these swamp and marsh areas should continue to be drained, *or* those who feel they should be preserved in their natural state, *or* don't you have a strong feeling one way or the other?

Only 11 percent of the respondents stated that they had no strong feelings on the question. The preservation of wetlands received very strong support, with 65 percent favoring preservation and 10 percent supporting their development. On a related topic, a large majority agreed that "an endangered species should be protected even at the expense of commercial activity." In 1980, 73 percent took this position, slightly more than the 67 percent in an RFF national survey in 1978.

ENERGY

Although there is firm public support for environmental regulation despite its recognized costs and although the public is unwilling to sacrifice environmental standards for economic growth, answers to various energy tradeoff questions indicate that the public does not generally favor protecting the environment at the expense of an adequate supply of energy. However, opinion is divided, and the proportion leaning to one side or the other of the energy-environment tradeoff varies with the question wording and energy-related events at the time of the poll.

A question which Roper has asked annually since 1973 is: "Are you more on the side of adequate energy or more on the side of protecting the environment?" In 10 surveys conducted between October 1973 and September 1979, only once was environmental protection chosen by a plurality (1976). Otherwise, the results are similar to those of September 1979, when 43 percent chose "adequate energy," 38 percent chose "protecting the environment," and 10 percent said "neither" or "no conflict."

Five recent (1979-early 1980) polls with environment-energy tradeoff questions also showed public opinion leaning toward energy development, with strong majorities favoring energy in two and a much closer division in three. Three of them were taken in July 1979, shortly after a period of trying gasoline shortages. One, a Harris poll, found that 61 percent of respondents favored slowing down the movement to clean up air and water pollution "it it could be shown that the country could cope with its energy problem more effectively," up from 45 percent who expressed this view in a 1976 Harris poll. Another poll found 55 percent of the respondents in favor of "relaxing laws and regulations designed to protect the environment in order to produce more energy."

A more general question was asked at this time by a CBS News-New York Times poll: "Which do you think is more important—producing energy or protecting the environment?" Here the results were a virtual standoff: 41 percent believed producing energy to be more important and 43 percent favored the environment. In September 1979, an NBC News poll asked whether "protecting the environment or building a needed refinery or pipeline" was more important. The pipeline was preferred by a margin of 47 to 40 percent. Yet another energy-environment tradeoff question was asked by the University of Michigan Election Study survey in late January-early February 1980, whether "you think the government should relax environmental protection regulations to increase the use of . . . energy sources, or should the government keep environmental protection regulations unchanged even though this may delay the production of more energy?" Here 29 percent favored unchanged environmental protection measures, 34 percent would relax them, and 15 percent would relax them but with qualifications; 22 percent were unsure or had no opinion on this question.

Each tradeoff question requires respondents to assume that the choice posed is one that has to be made. But most of these questions do not measure the belief—which a number of people may share—that energy development is not necessarily incompatible with environmental quality or that environmentally benign rather than environmentally risky energy sources should be pursued. As a way of testing public views on this subject, in 1980 RFF asked individuals to look ahead to the year 2000 and to select from seven energy sources the two or three that "we should concentrate on the most." They were then asked for the one that should receive "the least effort to develop." As indicated in Table 3, the most preferred energy source is also the most environmentally benign. Solar energy was chosen by two out of three people as one of two or three sources on which the nation should concentrate. This level of popularity is consistent with the results of other polls. Nuclear energy was chosen most often (by 33 percent) as the technology which should receive the least effort.

Table 3

Energy Sources Which Are Most and Least Preferred as National Priorities for the Year 2000 [1]

Q.40. Here is a list of several ways to get energy. (HAND RESPONDENT CARD) Looking ahead to the year 2000, and this nation's energy needs, which two or three of these sources of energy do you think we should concentrate on the most? (READ WHILE RESPONDENT LOOKS AT CARD:)

This list includes coal; nuclear energy; energy conservation steps such as more and better home insulation and cars that get good mileage; *water power* from dams or waterfalls; *solar energy* including energy from the sun and the wind; *oil and natural gas*; and *synfuels* which are a new kind of fuel made by industrial plants which convert oil shale into oil or coal to a liquid or gas. Which two or three do you think we should concentrate on the most?

Q.41. Now, looking at the card again, which one of these sources of energy would you like to see us spend the least effort to develop? (RECORD ABOVE)

Rank		40. Concentrate on most	41. Spend least effort	Most minus least
1	Solar energy	61%	6%	+55
2	Energy conservation	35	3	+32
3	Coal	36	9	+27
4	Water power	31	10	+21
5	Oil and natural gas	28	9	+19
6	Synfuels	26	5	+16
7	Nuclear energy	23	33	−10
	None	—	6	
	No opinion	2	15	

[1] 1980 RFF survey, N = 1,576.

A significant percentage of people appears to be willing, at least to some degree, to act upon their positive feelings about solar energy. The RFF survey asked homeowners (78 percent of the sample owned or expected to own their own homes shortly) whether they had considered installing a solar energy system of any kind for their homes and, if so, what their plans were. Nationally, 28 percent of homeowners said that they had considered installing a solar system. The figure breaks down as follows: 1 percent of all homeowners had already done so, 3 percent definitely planned to, 16 percent may install a solar system, and 8 percent had decided against a system. Individuals who had made positive decisions had higher incomes, were younger, and were particularly likely to have received more education than the others. Regionally, there was considerable variation—the Pacific and Mountain states had the highest percentage (29) of solar enthusiasts and the southern states the lowest (11).

Several questions in the RFF survey provide some insight into the reasons for nuclear power as the least preferred option for future energy development. Presented with four choices, 38 percent of respondents felt that nuclear power plants are "dangerous" or "not so safe" as solar power. Only 15 percent thought that they were "very safe," and 40 percent found them "somewhat safe." Paralleling these results, 20 percent of respondents said that all existing nuclear power plants should be shut down, 47 percent would use those that have been built but would build no more, and 23 percent said that building nuclear power plants should continue.

Public concerns about nuclear power plant safety are also suggested by answers to a question on siting, discussed below, in which a majority indicated that they would not want a nuclear power plant located within 100 miles of their homes.

CONCERN ABOUT ENVIRONMENTAL ISSUES

The positions that people take when presented with some of the alternatives and tradeoffs described above result from many factors, including how knowledgeable respondents are about the issues, how concerned they are about the problems, and how much faith they have in government ability to deal with them. RFF asked several questions to elicit some of these underlying feelings.

The 1980 RFF survey asked the respondents how worried or concerned they were about each of nine domestic problems. The survey repeated four items that Potomac Associates had asked at three points in the middle 1970s, as shown in Table 4.

Not surprisingly, 1980 respondents indicated a high level of concern about inflation; more than 80 percent were worried "a great deal" about it. This concern matches that shown during the 1974 recession.

Energy shortages are also of great concern in 1980. The increase from 57 percent in 1974 to 73 percent in 1980 parallels the findings of other polls and suggests that awareness of the seriousness of the energy problem is increasing. Concern about poverty, asked only in 1980, is significantly below the levels of concern for inflation and energy shortages; 44 percent of respondents were concerned "a great deal" about poverty.

RFF also surveyed public concern regarding six environmental problems. The items on air and water pollution had been asked in the Potomac Associates polls in 1972, 1974, and 1976. In January-February 1980, 38 percent of the public was concerned "a great deal" about reducing water pollution. In a regular Roper survey in late March 1980, when the same interviewers asked the same question of a different national sample, 54 percent expressed the same level of concern about water pollution. The difference between the January and March results is too large to be attributed to sampling error. The earlier 1980 results suggest that the intensity of conern about water pollution dropped from the 1972–76 levels; in contrast, the March 1980 data indicate that the intensity of concern has been relatively constant over these years.

There are two possible reasons for the different survey results. In the earlier RFF survey, Afghanistan and Iran were dominating the news and the polls. In this atypical climate of opinion, when concerns about the security of foreign relations and oil supplies were unusually high, concern about environmental issues may have been somewhat attenuated.

The second and more likely possibility is that the sequence of questions in the initial RFF survey affected results. Unlike most surveys on this topic, RFF began by asking respondents to rank pollution *relative to* other social problems such as national defense and the economy. The concern question immediately followed the comparison questions. In this context, environmental issues may have appeared somewhat less pressing. Questions in the March Roper survey, like most other surveys on this topic, including the Potomac Associates surveys in earlier years, did not ask for comparisons. A small ($N = 287$) supplementary survey in late March using the initial RFF sequence of questions confirmed the tempering effect of comparison questions. Accordingly, data from the initial 1980 RFF survey may represent a more "realistic" measure of concern; the Roper data, collected a few weeks later, may be more comparable to surveys of earlier years and therefore are more appropriate to trends evaluation.

Table 4

Percent Saying That They Are Worried a Great Deal, Not Much, or Not at All about Various Domestic Problems, 1972–80, Ranked by Degree of Concern in 1980[1]

Q.11. Now, I'd like to find out how worried or concerned you are about a number of problems I am going to mention: *a great deal, a fair amount, not very much,* or *not at all.* If you aren't really concerned about some of these matters, don't hesitate to say so.

Question	Response	1972 June	1974 April	1976 May	1980 Jan.–Feb.	1980 Mar.
a. How worried are you about the rise in prices and the cost of living?	A great deal		83%	75%	81%	86%
	Not much, not at all		4	4	3	3
b. Shortages of oil, gasoline, coal, natural gas, electricity, or other fuels?	A great deal		57		73	
	Not much, not at all		17		7	
c. The disposal of industrial chemical wastes that are hazardous?	A great deal					64
	Not much, not at all					9
d. Cleaning up our waterways and reducing water pollution?	A great deal	61%	51	57	39	54
	Not much, not at all	8	12	9	16	12
e. The presence of toxic chemicals such as pesticides or PCBs in the environment?	A great deal					46
	Not much, not at all					20
f. The problems of the poor?	A great deal				44	
	Not much, not at all				13	
g. The purity of the drinking water in your community?	A great deal				42	
	Not much, not at all				29	
h. Reducing air pollution?	A great deal	60	46	55	36	
	Not much, not at all	10	15	11	23	
i. Reducing the amount of unnecessary noise in this community?	A great deal				11	
	Not much, not at all				58	
N =		1,802	1,865	1,071	1,576	2,003

[1] Data for 1972–76 are from the "State of the Nation" studies done by Potomac Associates. A dash indicates that the item was not included in a survey. The data labeled January–February are from the RFF survey for CEQ and include 287 additional interviews in late March. The data labeled March 1980 are from a regular Roper survey. The four items asked in March were included because two of them had been inadvertently omitted in the January–February RFF survey. The other two, on inflation and water pollution, were included for comparative purposes.

With these factors in mind, the following conclusions may be drawn regarding public concern about the six environmental problems:

- There has been no decline in concern about water pollution since 1974 and 1976.
- Although air pollution was not included in the March 1980 Roper survey, which forms the basis for comparison, it appears from other evidence that there has been some decline in concern about air pollution.
- Concern about the disposal of industrial hazardous chemical wastes in 1980 is very high—64 percent expressed "a great deal" of concern about it in the Roper survey. This level is higher than has been expressed for air and water pollution in past surveys. Other results, described below, confirm this finding.
- There is substantial concern about toxic chemicals in the environment in 1980.
- There is also substantial concern about drinking water quality.
- A small but distinct minority is concerned "a great deal" about noise pollution.

In 1980, levels of concern about these same environmental issues are fairly evenly distributed (within 5 percentage points of the mean) across sex, race, age, income, education, and rural-urban categories. The following are the major exceptions to this generalization:

- Blacks are much more concerned than whites about the purity of drinking water and noise pollution. Two out of three blacks are concerned "a great deal" about drinking water purity, compared with one in three whites.
- People who live in cities of 250,000 or more and in their suburbs are much more concerned about air pollution, toxic chemicals in the environment, and drinking water purity than those who live in rural areas.
- Older middle-aged people (55–64) are particularly concerned about the disposal of chemical wastes; the 18–34 age group is significantly more concerned about air pollution than its elders.

SITING

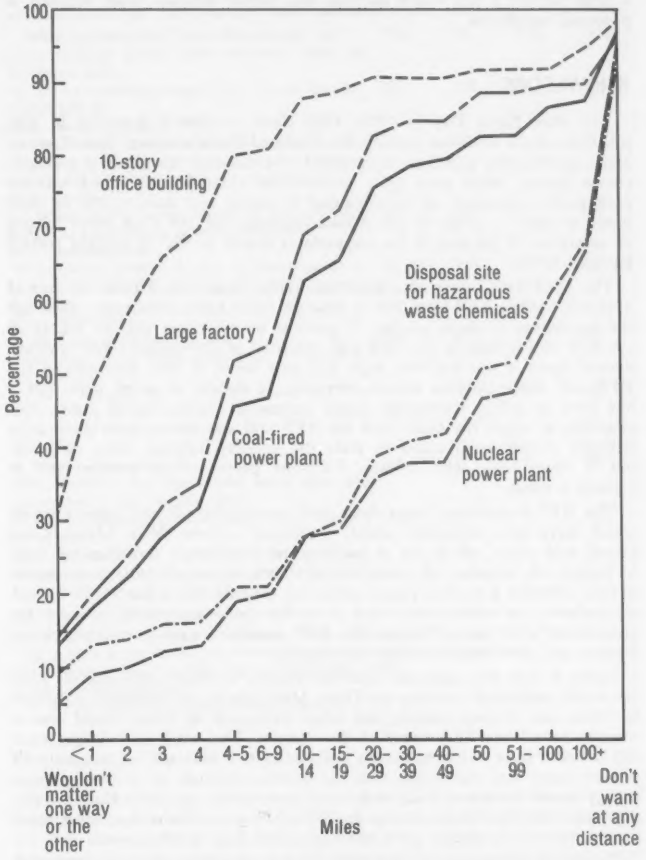
Another way of measuring public concern on environmental issues is to ask how people feel about living near facilities that may emit pollutants or pose some other kind of safety or environmental risk. Previous national surveys—at least those that are publicly available—rarely measured public views in this way. RFF asked individuals to say how near their homes five facilities could be sited before they would "want to move to another place or to actively protest, or wouldn't it matter to you one way or another how close it was?" Each of the five installations—a 10-story office building, a large factory, a coal-fired power plant, a nuclear power plant, and a hazardous waste disposal site—would be built and operated according to government environmental and safety regulations.

Figure 3 shows respondents' willingness to accept the various installations. Reactions to the different types of facilities differ strikingly. People objected the least to the office building and the most to the nuclear power plant and hazardous waste disposal site. For the 10-story office building, 31 percent said that it would not matter how near the building was located. Another 17 percent said that they would not be inclined to move or to protest if the building were located within 1 mile of their homes. As the figure shows, at a distance of 14 miles, 88 percent were willing to accept the construction of a 10-story office building; at the other extreme, 4 percent did not want it at any distance.

In contrast, only 5 percent and 10 percent, respectively, of respondents did not care how near a hazardous waste dump or a nuclear power plant was

Figure 3

Cumulative Percentage of People Willing To Accept New Industrial Installations at Various Distances from Their Homes



located. Aversion to the siting of a disposal site for hazardous waste chemicals is very strong despite the fact that respondents were given special assurances about this kind of installation—that "disposal could be done safely and that the site would be inspected regularly for possible problems." A lower percentage of people accepted a disposal site within 5 miles of their homes than any of the other installations, although beyond 5 miles reactions to the disposal site and the nuclear power plant were almost identical. Neither reached majority acceptance until the distance exceeded 100 miles.

People are much more averse to the siting of a nuclear power plant near their homes than they are to the siting of a coal-fired plant. Although only 28 percent would accept a nuclear power plant within 14 miles, 63 percent would accept a coal-fired plant within that distance. Taking into account the difference in wording of the question, the percentage of people who would accept a coal-fired plant within 5 miles is near that found by Harris in 1978. The acceptance profile for the coal-fired plant is very similar to that for a large factory, a fact which suggests that people evaluate them similarly as potential neighbors.

KNOWLEDGE

Just after Earth Day in 1970, CBS News conducted a survey in conjunction with a television special, The National Environmental Test. Twenty-seven information questions were asked of a national sample in a multiple-choice format. Most were quite specific; for example, one asked whether earthquakes, corrosion, or stress caused by freeze and thaw would be most likely to cause a break in the Alaska pipeline. For the CBS News battery of questions, 18 percent of the respondents scored at the 70 percent correct level or better.

The 1980 RFF survey also asked knowledge questions. Unlike the test of a decade earlier, RFF intended to measure fairly basic knowledge. Although the percentage of those scoring 70 percent or more was slightly higher in the RFF survey than in the CBS poll, the level of knowledge about environmental issues is still not very high. On only three of nine questions in the RFF poll did majorities answer correctly. It should be noted here that a low level of public knowledge is not unique to environmental issues. For example, at about the same time the RFF poll was taken, individuals in a national sample were asked to state the current inflation rate; only one out of three knew what it was. Fifty-one percent were unable even to venture a guess.

The RFF knowledge items dealt with environmental and energy topics which have been relatively widely publicized (Three Mile Island, Love Canal, acid rain), which are of fundamental importance (whether we have to import oil; whether all, most, or only some chemicals can cause cancer in rats; whether a nuclear power plant can explode like a bomb; the nature of synfuels), or which were used in earlier polls and could be used for comparison over time. Five of the RFF questions used a multiple-choice format, and the other four were open ended.

Table 5 lists the questions and the results. At the beginning of 1980 the much publicized accident at Three Mile Island was correctly identified by three out of four people, but what happened at Love Canal was a mystery to all but 22 percent of the sample. The other knowledge items fall between these extremes. Seven years after the Arab oil boycott, only 63 percent knew that the nation does not produce enough oil to meet present energy needs. However, judging by data from 1977 and 1978 Gallup polls, awareness seems to be increasing. In 1977, 52 percent knew that the United States imports oil, and in 1978, the figure had risen to 60 percent.

Judging from responses in the 1970 CBS News poll and in the 1980 RFF survey, the public is not necessarily more knowledgeable about air pollution today than it was 10 years ago. In 1980, 45 percent of the respondents knew that automobiles (rather than factories or incinerators) are the major cause of air pollution, compared to 55 percent in 1970. However, there was a 20 percent increase from 1970 to 1980 in those who knew that nuclear power plants are built near water because they need water "for cooling purposes" rather than as "another source of power" or "as a disposal place for waste." Yet in 1980 only one in three people was aware of the

Table 5

Environmental and Energy Knowledge Questions

Paraphrase of question [1]	Correct	Partially correct	Incorrect	Don't know
1. What happened at Three Mile Island? (E) (Ans.: Nuclear power plant accident, close to meltdown, etc.)	74%	3%	4%	19%
*2. Do we produce enough oil or do we have to import oil? (E) (Ans.: Have to import)	63	NA	29	7
*3. Are nuclear power plants built near bodies of water because water is used as a power source, for waste deposit or for cooling? (E) (Ans.: Cooling)	52	NA	27	21
*4. Which is the major source of air pollution: factories, automobiles or incinerators? (Ans.: Automobiles)	45	NA	46	9
*5. Is cancer caused in rats by every, most or only some chemicals if fed in large enough doses? (G) (Ans.: Only some)	42	NA	45	12
6. What are synthetic fuels? (E) (Ans.: Gas or oil made from coal, oil shale or tar sands)	37	5	15	42
*7. Is it possible for a nuclear power plant to explode and cause a mushroom-shaped cloud like the one at Hiroshima? (E) (Ans.: No)	31	NA	52	16
8. What is acid rain? (G) (Ans.: Polluted rain that harms lakes, land and water; that is like vinegar, etc.)	26	6	9	58
9. What happened at Love Canal, near Niagara Falls? (G) (Ans.: Chemical or toxic waste dump, place where chemical wastes harmed people or made them move, etc.)	22	4	8	65

[1] With the exception of Question 1, each was asked of only one-half the sample.
G = Part of the three-item General Environmental Knowledge Scale.
E = Part of the five-item Energy Knowledge Scale.
NA = Not applicable.
* = Presented in a multiple-choice format.

fact that it is impossible for a nuclear power plant to explode like an atomic bomb.

For the five energy questions, 28 percent of the respondents answered none or only one correctly; 32 percent answered four or all five correctly. Of the three general environmental questions, one-third of the sample answered all three incorrectly and 29 percent knew the correct answer to at least two of the three. Although, as expected, a high knowledge score correlates with an individual's educational level, neither of these scales is correlated with people's views about environmental protection or the environmental movement. Individuals in favor of environmental protection were no more or no less knowledgeable than those who are less in favor of it.

As noted, the relatively low levels of knowledge about the environment are consistent with the levels found in other policy areas. Simply because the public has a relatively low level of knowledge in a policy area, public

opinion on the issues is not invalid. Just as people have opinions about inflation even though they may not know the current rate of inflation within several percentage points, so their views on waste dumps for hazardous chemicals should be taken seriously even though they may not be able to say what happened at Love Canal. Nevertheless, because opinion based on knowledge is highly desirable, the knowledge findings in the RFF survey challenge environmental educators and others concerned with dissemination of information on these issues.

REGULATORY PERFORMANCE

Much discussion has centered on federal regulatory and environmental programs—whether the public has confidence in the programs, believes that they adequately reflect public views, and considers them necessary.

A new and controversial area of government regulation is the testing and control of chemicals that may cause cancer or otherwise seriously threaten human health or the environment. The RFF survey, prefacing its question with a warning that screening of chemicals is costly and "might keep potentially useful chemicals off the market," asked whether individuals think that the government should "wait until a chemical is already in use and has been shown to present a problem before taking action" or whether the government should "conduct an extensive screening program to try and make sure all chemicals are safe before they are used." An overwhelming 83 percent felt that all chemicals should be screened before use. Only 8 percent would wait until there is a problem before taking action (the remaining 8 percent either had no opinion or did not subscribe to either view).

The RFF survey also probed public views on government action regarding chemicals, including saccharin, which were described as causing cancer in some people. Eighty to 90 percent of the respondents favored some government control, with the percentages favoring warning labels and outright bans varying by chemical; the figures are shown in Table 6.

Overall, as shown in Figure 4, the public seems confident that the federal government will be able to protect the environment (67 percent had "a great deal" or "some" confidence), and it is even more confident that the government will "find a satisfactory way to meet our future energy needs" (71 percent have "a great deal" or "some" confidence).

Yet far fewer people believe that the government is responsive to the public's views. Less than a majority of respondents (44 percent) felt that the federal government provides "citizens like you" with "a great deal" or "some" opportunity to express their views on environmental issues. Still fewer thought that the views of individuals are heard, and only one in three believes that their views would be paid a "great deal" or "some" attention. Respondents felt that the government pays attention to the views of national environmental groups, however. In this case almost three out of four people believe that the groups are listened to "a great deal" or "some."

THE ENVIRONMENTAL MOVEMENT

Public support for the environmental movement has remained strong over the decade, according to all available evidence. Asked by RFF whether they consider themselves active environmentalists, sympathetic to the environmental movement, neutral, or unsympathetic to the movement, 6 out of 10 people (62 percent) said that they are active or sympathetic, a level of support that is almost identical to that found in 1978 when this question was first asked by RFF. The 7 percent in the 1980 survey who

Table 6

Views on Regulation of Cancer-Causing Chemicals

Q.37. I am going to describe four different kinds of chemicals which studies have shown to cause cancer in some people. I would like you to tell me which one of the approaches listed on this card you think the Federal Government should take for each chemical. The first approach is that the government should ban certain uses of the chemical. The second is that the government should require clear warning labels on all products using the chemical but let them continue to be sold. The third approach is that the government should not regulate the chemical at all.

Chemical	Ban	Warning label	Not regulate	No opinion
a. The first kind of chemical that has been shown to cause cancer is one commonly used to preserve food like bacon. Which one approach should the government take? (PROBE: That is, chemicals like nitrites)	33%	57%	5%	5%
b. The second is a chemical used as an ingredient in some hair dyes	31	60	3	6
c. The third is saccharin	16	66	12	7
d. The fourth is a chemical used to color food like hot dogs, soft drinks and ice cream. (PROBE: That is, Red Dye #2)	47	44	4	5

regarded themselves as "active participants in the movement" is lower than the 1978 figure of 13 percent. However, there is no increase in those who say they are unsympathetic to the movement. In 1978, 6 percent took this position, and in 1980 it was 4 percent. Unlike the anti-nuclear movement about which opinion is polarized, the environmental movement continues to enjoy a very high level of support and an extraordinarily small amount of opposition from the public. This fact is confirmed by another question in the RFF survey which asked individuals whether being an environmentalist "definitely applies to you somewhat, or not at all." In response, 18 percent said "definitely" and 55 percent said "somewhat," for a total of 73 percent who accept the environmentalist label, at least in part.

Not only is support for the environmental movement strong; it is quite broad based. Figure 5 shows the percentages of the population who are sympathetic, unsympathetic, and active by category. Only among blacks, individuals with less than a high school education, and residents of the East South Central states (Mississippi to Kentucky) are fewer than 50 percent of the respondents sympathetic to the movement. For no category was more than 6 percent unsympathetic.

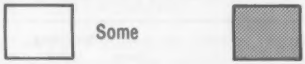
In the RFF survey one form of individual participation in environmental matters—writing letters to public officials—was measured. People were asked whether they "had occasion to write a letter or contact a public official directly about an environmental matter or not" in the past 2 years. Overall, 12 percent said that they had done so. A followup question asked whether the letter supported or opposed greater environmental protection. Nine letters in 10 favored more environmental protection. Those who said that they had written letters tended to be in the higher income brackets and, especially, to have more education. Forty-two percent of those who regard themselves as environmental activists said that they have contacted a public official in the last 2 years.

Another form of participation in environmental efforts is collecting newspapers or bottles for recycling. Almost one-half the respondents (49 percent) said that they have done so at least once in the past 2 years. Among

Figure 4

Views about Public Participation and Government Effectiveness in Environmental and Energy Policy[1]

According to what you have heard or read or know from your own experience, how much...



Q.47 Opportunity does the Federal Government provide to citizens like you to express their views on environmental issues?

Q.48 Attention do you think the Federal Government gives to the views of individual citizens like you on environmental issues?

Q.49 Attention do you think the Federal Government gives to the views of national groups like the Sierra Club, the National Wildlife Federation or the National Audubon Society?

Q.50 Confidence do you have that the Federal Government will provide sufficient protection for our natural environment?

Q.51 Confidence do you have that the Federal Government will find a satisfactory way to meet our future energy needs?

[1]RFF survey. These questions were asked only in the Y version of the questionnaire, N = 736. Respondents were given four answer categories: a great deal, some, little, none at all. The percentage of those who volunteered "it depends" or had no opinion varied from 3 to 7.

Figure 5

Views of the Environmental Movement[1]

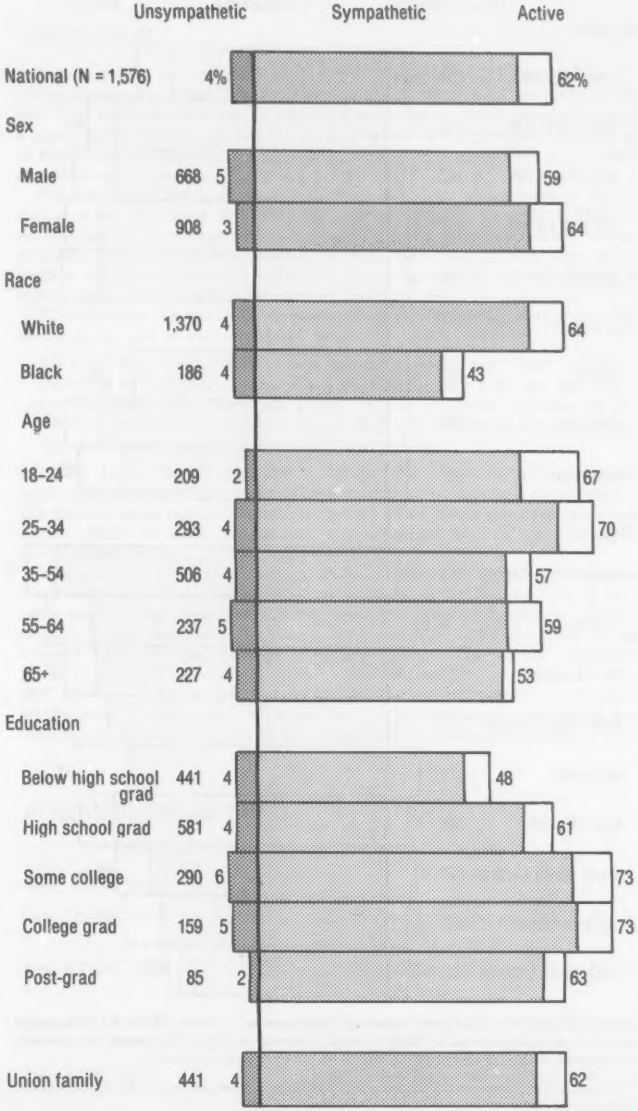
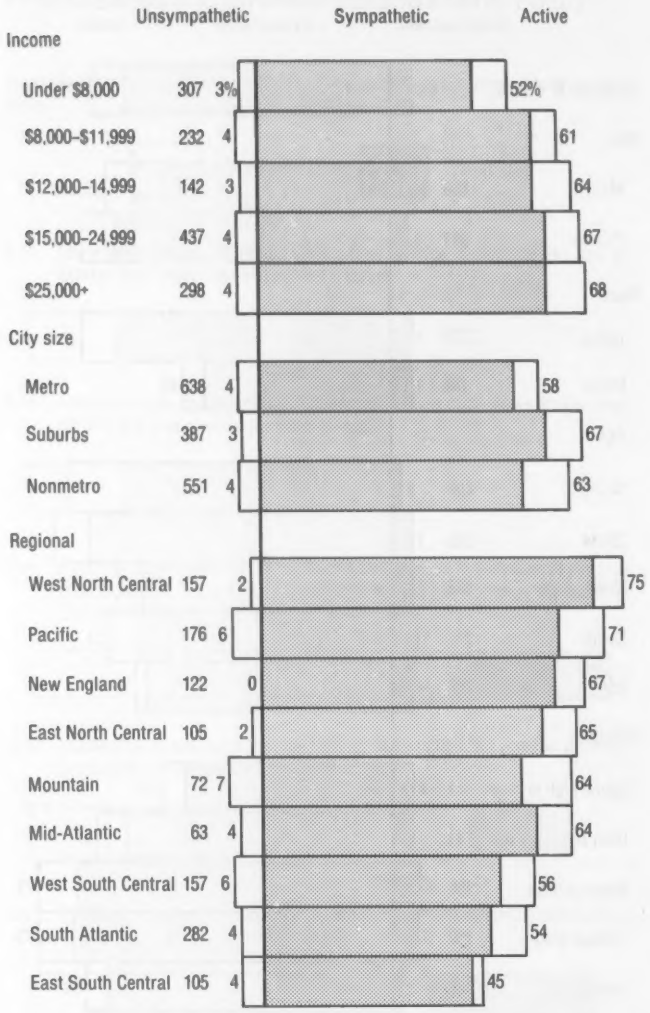


Figure 5 (continued)

Views of the Environmental Movement[1]



[1]RFF survey, Q. 54. In recent years, the environmental movement has been very active. Do you think of yourself as: an active participant in the environmental movement, sympathetic towards the movement but not active, neutral, or unsympathetic towards the environmental movement?

The categories not shown on this figure and the national percentages are: neutral, 31 percent; not sure, 3 percent.

environmental activists, the total was 69 percent, and even many of those who are unsympathetic to the environmental movement said that they had recycled newspaper or bottles in the past 2 years (38 percent).

CONCLUSION

Polls are one way of measuring public views of social issues. Like all methods, they have strengths and weaknesses. Among their strengths is the fact that through their use of scientific sampling methods they can reach a truly representative sample of the population and aggregate the feelings of those who are inarticulate as well as those who express their views freely in a variety of forums.

Poll results are highly dependent upon the wording of questions, of course, and it is at this point that they are most vulnerable to misuse. Only by examining a wide range of questions, by using questions which employ tradeoffs, and by comparing answers to the same question over time to ascertain trends—techniques emphasized here—can a valid overall picture of public views on environmental matters be developed.

The Opinion Research Corporation gave the following advice in 1977 based on its poll of environmental issues:

> All told, if public opinion is any guide, it would seem that business continues to have little recourse but to learn to cope with the fact that environmental protection no longer is the exclusive domain of a handful of professional social critics and environmental activists, but the continuing concern of the public as a whole.

In 1978 Louis Harris said that although the public is willing to take many risks because of the energy shortage, it is also shaking a stern finger in the face of those responsible and is saying: "But don't you dare relax your all-out efforts to make certain that environmental hazards are kept to an absolute minimum."

The results of the RFF survey in 1980 are consistent with these generalizations. Although the state of the environment is no longer viewed as a crisis issue, strong support for environmental protection continues. There is no sign of the backlash which had been predicted once the costs of significant environmental protection became known. The overall impression given by the RFF survey and by the other polls at the end of the 1970s is that far from being a fad, the enthusiasm for environmental improvement which arose in the early 1970s has become a continuing concern—a concern which shows every sign of remaining for the foreseeable future.

APPENDIX: POLLS CITED

Field date	Source
ABC News/Harris	
Oct. 16–26, 1978	ABC News/Harris Survey Vol. I, No. 2 (Jan. 4, 1979)
Jan. 17–22, 1979	ABC News/Harris Survey Vol. I, No. 16 (Feb. 8, 1979)
June 13–17, 1979	ABC News/Harris Survey Vol. I, No. 80 (July 2, 1979)
July 7–15, 1979	ABC/News Harris Survey Vol. I, No. 109 (Sept. 4, 1979)

Field date	Source
July 7–15, 1979	ABC News/Harris Survey Vol. I, No. 110 (Sept. 6, 1979)
CBS News/New York Times Polls	
April 28–29, 1970	Robert Chandler, *Public Opinion: Attitudes on Contemporary Political and Social Issues* (New York: R.R. Bowker, 1972)
July 1979	*Public Opinion* Aug./Sept. 1979, p. 23
April 10–14, 1980	News Release: CBS News/New York Times Poll, April 1980 (Parts I and II)
Center for Policy Studies of the Institute for Social Research, University of Michigan	
January–February 1980	1980 American National Election Study, January-February 1980 Survey (initial tabulations)
Gallup	
April 2–7, 1965	*The Gallup Poll: Public Opinion 1935–1971* (New York: Random House, 1972), p. 1939
April 29–May 5, 1970	*Ibid.*, p. 2248
July 18–19, 1979	*Newsweek*, July 30, 1979
Aug. 3–6, 1979	*Gallup Opinion Index*, No. 170
Feb. 1–11, 1980	*Newsweek*, March 3, 1980
NBC News/Associated Press	
Sept. 10–11, 1979	News Release: NBC News/Associated Press Poll No. 121, September 1979
National Opinion Research Center, University of Chicago	
1973–1978, 1980	General Social Survey; annual 1973–1978, biannual beginning 1980. Data provided by NORC in advance of official release
Opinion Research Corporation	
May 30–June 22, 1975	*ORC Public Opinion Index*, Vol. 33, No. 16 (August 1975)
Jan. 7–14, 1978	*ORC Public Opinion Index*, Vol. 35, Nos. 3 and 4 (February 1978)
August 1979	Data provided by ORC

Potomac Associates	
June 1972	William Watt and Lloyd A. Free, *State of the Nation* (New York: Universe Books, 1973) [field work by Gallup]
April 1974	William Watt and Lloyd A. Free, *State of the Nation 1974* (Washington, D.C.: Potomac Associates, 1974) [field work by Gallup]
May 1976	Gladwin Hill, Lloyd A. Free, and Donald R. Lesh, *Policy Perspectives, Protecting the Environment: Progress, Prospects and the Public View* (Washington, D.C.: Potomac Associates, 1977) [field work by Gallup]
Resources for the Future	
July 7–Aug. 10, 1978	*Resources* (Resources for the Future, No. 60) September–October 1978
The Roper Organization	
Sept. 22–28, 1979	*Roper Reports* 79 (9), September 1979 Special tabulation for Resources for the Future
Roger Seasonwein Associates	
Sept. 26–Oct. 28, 1979	Roger Seasonwein Associates, *The Vital Consensus: American Attitudes on Economic Growth* (New York: Union Carbide Corp., 1980), p. 55
Nov. 5–25, 1979	Roger Seasonwein Associates, *The Conservation Decision* (New York: Union Carbide Corp., 1979), p. 11 ff
U.S. Soil Conservation Service	
Oct. 19–Nov. 21, 1979	U.S. Soil Conservation Service Press Release, January 17, 1980 (conducted by Louis Harris and Associates)

APPENDIX B

THE NATIONAL ENVIRONMENTAL POLICY ACT OF 1969, AS AMENDED*

An Act to establish a national policy for the environment, to provide for the establishment of a Council on Environmental Quality, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "National Environmental Policy Act of 1969."

PURPOSE

SEC. 2. The purposes of this Act are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality.

TITLE I

DECLARATION OF NATIONAL ENVIRONMENTAL POLICY

SEC. 101. (a) The Congress, recognizing the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding technological advances and recognizing further the critical importance of restoring and maintaining environmental quality to the overall welfare and development of man, declares that it is the continuing policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans.

(b) In order to carry out the policy set forth in this Act, it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may—

(1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;

*Pub. L. 91–190, 42 U.S.C. 4321–4347, January 1, 1970, as amended by Pub. L. 94–52, July 3, 1975, and Pub. L. 94–83, August 9, 1975.

(2) assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings;

(3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;

(4) preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice;

(5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and

(6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

(c) The Congress recognizes that each person should enjoy a healthful environment and that each person has a responsibility to contribute to the preservation and enhancement of the environment.

SEC. 102. The Congress authorizes and directs that, to the fullest extent possible: (1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in this Act, and (2) all agencies of the Federal Government shall—

(A) Utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment;

(B) Identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by title II of this Act, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical considerations;

(C) Include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on—

(i) The environmental impact of the proposed action,

(ii) Any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) Alternatives to the proposed action,

(iv) The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Prior to making any detailed statement, the responsible Federal official shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Copies of such statement and the comments and views of the appropriate Federal, State, and local agencies, which are authorized to develop and enforce environmental standards, shall be made available to the President, the Council on Environmental Quality and to the public as provided by section 552 of title 5, United States Code, and shall accompany the proposal through the existing agency review processes;

(D) Any detailed statement required under subparagraph (c) after January 1, 1970, for any major Federal action funded under a program of grants to States shall not be deemed to be legally insufficient solely by reason of having been prepared by a State agency or official, if:

(i) the State agency or official has statewide jurisdiction and has the responsibility for such action,

(ii) the responsible Federal official furnishes guidance and participates in such preparation,

(iii) the responsible Federal official independently evaluates such statement prior to its approval and adoption, and

(iv) after January 1, 1976, the responsible Federal official provides early notification to, and solicits the views of, any other State or any Federal land management entity of any action or any alternative thereto which may have significant impacts upon such State or affected Federal land management entity and, if there is any disagreement on such impacts, prepares a written assessment of such impacts and views for incorporation into such detailed statement.

The procedures in this subparagraph shall not relieve the Federal official of his responsibilities for the scope, objectivity, and content of the entire statement or of any other responsibility under this Act; and further, this subparagraph does not affect the legal sufficiency of statements prepared by State agencies with less than statewide jurisdiction.

(E) Study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources;

(F) Recognize the worldwide and long-range character of environmental problems and, where consistent with the foreign policy of the United States, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment;

(G) Make available to States, counties, municipalities, institutions, and individuals, advice and information useful in restoring, maintaining, and enhancing the quality of the environment;

(H) Initiate and utilize ecological information in the planning and development of resource-oriented projects; and

(I) Assist the Council on Environmental Quality established by title II of this Act.

SEC. 103. All agencies of the Federal Government shall review their present statutory authority, administrative regulations, and current policies and procedures for the purpose of determining whether there are any deficiencies or inconsistencies therein which prohibit full compliance with the purposes and provisions of this Act and shall propose to the President not later than July 1, 1971, such measures as may be necessary to bring their authority and policies into conformity with the intent, purposes, and procedures set forth in this Act.

SEC. 104. Nothing in section 102 or 103 shall in any way affect the specific statutory obligations of any Federal agency (1) to comply with criteria or standards of environmental quality, (2) to coordinate or consult with any other Federal or State agency, or (3) to act, or refrain from acting contingent upon the recommendations or certification of any other Federal or State agency.

SEC. 105. The policies and goals set forth in this Act are supplementary to those set forth in existing authorizations of Federal agencies.

TITLE II

COUNCIL ON ENVIRONMENTAL QUALITY

SEC. 201. The President shall transmit to the Congress annually beginning July 1, 1970, an Environmental Quality Report (hereinafter referred to as the "report") which shall set forth (1) the status and condition of the major natural, manmade, or altered environmental classes of the Nation, including, but not limited to, the air, the aquatic, including marine, estuarine, and fresh water, and the terrestrial environment, including, but not limited to, the forest, dryland, wetland, range, urban, suburban and rural environment; (2) cur-

rent and foreseeable trends in the quality, management and utilization of such environments and the effects of those trends on the social, economic, and other requirements of the Nation; (3) the adequacy of available natural resources for fulfilling human and economic requirements of the Nation in the light of expected population pressures; (4) a review of the programs and activities (including regulatory activities) of the Federal Government, the State and local governments, and nongovernmental entities or individuals with particular reference to their effect on the environment and on the conservation, development and utilization of natural resources; and (5) a program for remedying the deficiencies of existing programs and activities, together with recommendations for legislation.

SEC. 202. There is created in the Executive Office of the President a Council on Environmental Quality (hereinafter referred to as the "Council"). The Council shall be composed of three members who shall be appointed by the President to serve at his pleasure, by and with the advice and consent of the Senate. The President shall designate one of the members of the Council to serve as Chairman. Each member shall be a person who, as a result of his training, experience, and attainments, is exceptionally well qualified to analyze and interpret environmental trends and information of all kinds; to appraise programs and activities of the Federal Government in the light of the policy set forth in title I of this Act; to be conscious of and responsive to the scientific, economic, social, esthetic, and cultural needs and interests of the Nation; and to formulate and recommend national policies to promote the improvement of the quality of the environment.

SEC. 203. The Council may employ such officers and employees as may be necessary to carry out its functions under this Act. In addition, the Council may employ and fix the compensation of such experts and consultants as may be necessary for the carrying out of its functions under this Act, in accordance with section 3109 of title 5, United States Code (but without regard to the last sentence thereof).

SEC. 204. It shall be the duty and function of the Council—

(1) to assist and advise the President in the preparation of the Environmental Quality Report required by section 201 of this title;

(2) to gather timely and authoritative information concerning the conditions and trends in the quality of the environment both current and prospective, to analyze and interpret such information for the purpose of determining whether such conditions and trends are interfering, or are likely to interfere, with the achievement of the policy set forth in title I of this Act, and to compile and submit to the President studies relating to such conditions and trends;

(3) to review and appraise the various programs and activities of the Federal Government in the light of the policy set forth in title I of this Act for the purpose of determining the extent to which such programs and activities are contributing to the achievement of such policy, and to make recommendations to the President with respect thereto;

(4) to develop and recommend to the President national policies to foster and promote the improvement of environmental quality to meet the conservation, social, economic, health, and other requirements and goals of the Nation;

(5) to conduct investigations, studies, surveys, research, and analyses relating to ecological systems and environmental quality;

(6) to document and define changes in the natural environment, including the plant and animal systems, and to accumulate necessary data and other information for a continuing analysis of these changes or trends and an interpretation of their underlying causes;

(7) to report at least once each year to the President on the state and condition of the environment; and

(8) to make and furnish such studies, reports thereon, and recommendations with respect to matters of policy and legislation as the President may request.

SEC. 205. In exercising its powers, functions, and duties under this Act, the Council shall—

(1) Consult with the Citizens' Advisory Committee on Environmental Quality established by Executive Order No. 11472, dated May 29, 1969, and with such representatives of science, industry, agriculture, labor, conservation organizations, State and local governments and other groups, as it deems advisable; and

(2) Utilize, to the fullest extent possible, the services, facilities and information (including statistical information) of public and private agencies and organizations, and individuals, in order that duplication of effort and expense may be avoided, thus assuring that the Council's activities will not unnecessarily overlap or conflict with similar activities authorized by law and performed by established agencies.

SEC. 206. Members of the Council shall serve full time and the Chairman of the Council shall be compensated at the rate provided for Level II of the Executive Schedule Pay Rates (5 U.S.C. 5313). The other members of the Council shall be compensated at the rate provided for Level IV of the Executive Schedule Pay Rates (5 U.S.C. 5315).

SEC. 207. The Council may accept reimbursements from any private nonprofit organization or from any department, agency, or instrumentality of the Federal Government, any State, or local government, for the reasonable travel expenses incurred by an officer or employee of the Council in connection with his attendance at any conference, seminar, or similar meeting conducted for the benefit of the Council.

SEC. 208. The Council may make expenditures in support of its international activities, including expenditures for: (1) international travel; (2) activities in implementation of international agreements; and (3) the support of international exchange programs in the United States and in foreign countries.

SEC. 209. There are authorized to be appropriated to carry out the provisions of this chapter not to exceed $300,000 for fiscal year 1970, $700,000 for fiscal year 1971, and $1,000,000 for each fiscal year thereafter.

APPENDIX C

THE ENVIRONMENTAL QUALITY IMPROVEMENT ACT OF 1970*

TITLE II—ENVIRONMENTAL QUALITY (OF THE WATER QUALITY IMPROVEMENT ACT OF 1974)

SHORT TITLE

SEC. 201. This title may be cited as the "Environmental Quality Improvement Act of 1970."

FINDINGS, DECLARATIONS, AND PURPOSES

SEC. 202. (a) The Congress finds—

(1) That man has caused changes in the environment;

(2) That many of these changes may affect the relationship between man and his environment; and

(3) The population increases and urban concentration contribute directly to pollution and the degradation of our environment.

(b)(1) The Congress declares that there is a national policy for the environment which provides for the enhancement of environmental quality. This policy is evidenced by statutes heretofore enacted relating to the prevention, abatement, and control of environmental pollution, water and land resources, transportation, and economic and regional development.

(2) The primary responsibility for implementing this policy rests with State and local governments.

(3) The Federal Government encourages and supports implementation of this policy through appropriate regional organizations established under existing law.

(c) The purposes of this title are—

(1) To assure that each Federal department and agency conducting or supporting public works activities which affect the environment shall implement the policies established under existing law; and

(2) To authorize an Office of Environmental Quality, which, notwithstanding any other provision of law, shall provide the professional and administrative staff for the Council on Environmental Quality established by Public Law 91–190.

OFFICE OF ENVIRONMENTAL QUALITY

SEC. 203. (a) There is established in the Executive Office of the President an office to be known as the Office of Environmental Quality (hereafter in this

*Pub. L. 91–224, 42 U.S.C. 4371–4374, April 3, 1970.

title referred to as the "Office"). The Chairman of the Council on Environmental Quality established by Public Law 91–190 shall be the Director of the Office. There shall be in the Office a Deputy Director who shall be appointed by the President, by and with the advice and consent of the Senate.

(b) The compensation of the Deputy Director shall be fixed by the President at a rate not in excess of the annual rate of compensation payable to the Deputy Director of the Bureau of the Budget.

(c) The Director is authorized to employ such officers and employees (including experts and consultants) as may be necessary to enable the Office to carry out its functions under this title and Public Law 91–190, except that he may employ no more than 10 specialists and other experts without regard to the provisions of title 5, United States Code, governing appointments in the competitive service, and pay such specialists and experts without regard to the provisions of chapter 51 and subchapter 111 of chapter 53 of such title relating to classification and General Schedule pay rates, but no such specialist or expert shall be paid at a rate in excess of the maximum rate for GS–18 of the General Schedule under section 5330 of title 5.

(d) In carrying out his functions the Director shall assist and advise the President on policies and programs of the Federal Government affecting environmental quality by—

(1) Providing the professional and administrative staff and support for the Council on Environmental Quality established by Public Law 91–190;

(2) Assisting the Federal agencies and departments in appraising the effectiveness of existing and proposed facilities, programs, policies, and activities of the Federal Government, and those specific major projects designated by the President which do not require individual project authorization by Congress, which affect environmental quality;

(3) Reviewing the adequacy of existing systems for monitoring and predicting environmental changes in order to achieve effective coverage and efficient use of research facilities and other resources;

(4) Promoting the advancement of scientific knowledge of the effects of actions and technology on the environment and encourage the development of the means to prevent or reduce adverse effects that endanger the health and well-being of man;

(5) Assisting in coordinating among the Federal departments and agencies those programs and activities which affect, protect, and improve environmental quality;

(6) Assisting the Federal departments and agencies in the development and interrelationship of environmental quality criteria and standards established through the Federal Government;

(7) Collecting, collating, analyzing, and interpreting data and information on environmental quality, ecological research, and evaluation.

(e) The Director is authorized to contract with public or private agencies, institutions, and organizations and with individuals without regard to sections 3618 and 3709 of the Revised Statutes (31 U.S.C. 529; 41 U.S.C. 5) in carrying out his functions.

REPORT

SEC. 204. Each Environmental Quality Report required by Public Law 91–190 shall, upon transmittal to Congress, be referred to each standing committee having jurisdiction over any part of the subject matter of the Report.

AUTHORIZATION

SEC. 205. There are hereby authorized to be appropriated not to exceed $500,000 for fiscal year ending June 30, 1970, not to exceed $750,000 for the fiscal year ending June 30, 1971, not to exceed $1,250,000 for the fiscal year

ending June 30, 1972, and not to exceed $1,500,000 for the fiscal year ending June 30, 1973. These authorizations are in addition to those contained in Public Law 91–190.

Approved April 3, 1970.

APPENDIX D

EXECUTIVE ORDER 11514, AS AMENDED BY EXECUTIVE ORDER 11991 (SECS. 2(g) AND 3(h)), MAY 24, 1977, PROTECTION AND ENHANCEMENT OF ENVIRONMENTAL QUALITY

By virtue of the authority vested in me as President of the United States and in furtherance of the purpose and policy of the National Environmental Policy Act of 1969 (Public Law No. 91–190, approved January 1, 1970), it is ordered as follows:

Section 1. *Policy.* The Federal Government shall provide leadership in protecting and enhancing the quality of the Nation's environment to sustain and enrich human life. Federal agencies shall initiate measures needed to direct their policies, plans and programs so as to meet national environmental goals. The Council on Environmental Quality, through the Chairman, shall advise and assist the President in leading this national effort.

Sec. 2. *Responsibilities of Federal agencies.* Consonant with Title I of the National Environmental Policy Act of 1969, hereafter referred to as the "Act", the heads of Federal agencies shall:

(a) Monitor, evaluate, and control on a continuing basis their agencies' activities so as to protect and enhance the quality of the environment. Such activities shall include those directed to controlling pollution and enhancing the environment and those designed to accomplish other program objectives which may affect the quality of the environment. Agencies shall develop programs and measures to protect and enhance environmental quality and shall assess progress in meeting the specific objectives of such activities. Heads of agencies shall consult with appropriate Federal, State and local agencies in carying out their activities as they affect the quality of the environment.

(b) Develop procedures to insure the fullest practicable provision of timely public information and understanding of Federal plans and programs with environmental impact in order to obtain the views of interested parties. These procedures shall include, whenever appropriate, provision for public hearings, and shall provide the public with relevant information, including information on alternative courses of action. Federal agencies shall also encourage State and local agencies to adopt similar procedures for informing the public concerning their activities affecting the quality of the environment.

(c) Insure that information regarding existing or potential environmental problems and control methods developed as part of research, development, demonstration, test, or evaluation activities is made available to Federal agencies, States, counties, municipalities, institutions, and other entities, as appropriate.

(d) Review their agencies' statutory authority, administrative regulations, policies, and procedures, including those relating to loans, grants,

contracts, leases, licenses, or permits, in order to identify any deficiencies or inconsistencies therein which prohibit or limit full compliance with the purposes and provisions of the Act. A report on this review and the corrective actions taken or planned, including such measures to be proposed to the President as may be necessary to bring their authority and policies into conformance with the intent, purposes, and procedures of the Act, shall be provided to the Council on Environmental Quality not later than September 1, 1970.

(e) Engage in exchange of data and research results, and cooperate with agencies of other governments to foster the purposes of the Act.

(f) Proceed, in coordination with other agencies, with actions required by section 102 of the Act.

(g) In carrying out their responsibilities under the Act and this Order, comply with the regulations issued by the Council except where such compliance would be inconsistent with statutory requirements.

Section 3. *Responsibilities of Council on Environmental Quality.* The Council on Environmental Quality shall:

(a) Evaluate existing and proposed policies and activities of the Federal Government directed to the control of pollution and the enhancement of the environment and to the accomplishment of other objectives which affect the quality of the environment. This shall include continuing review of procedures employed in the development and enforcement of Federal standards affecting environmental quality. Based upon such evaluations the Council shall, where appropriate, recommend to the President policies and programs to achieve more effective protection and enhancement of environmental quality and shall, where appropriate, seek resolution of significant environmental issues.

(b) Recommend to the President and to the agencies priorities among programs designed for the control of pollution and for enhancement of the environment.

(c) Determine the need for new policies and programs for dealing with environmental problems not being adequately addressed.

(d) Conduct, as it determines to be appropriate, public hearings or conferences on issues of environmental significance.

(e) Promote the development and use of indices and monitoring systems (1) to assess environmental conditions and trends, (2) to predict the environmental impact of proposed public and private actions, and (3) to determine the effectiveness of programs for protecting and enhancing environmental quality.

(f) Coordinate Federal programs related to environmental quality.

(g) Advise and assist the President and the agencies in achieving international cooperation for dealing with environmental problems, under the foreign policy guidance of the Secretary of State.

(h) Issue regulations to Federal agencies for the implementation of the procedural provisions of the Act (42 U.S.C. 4332(2)). Such regulations shall be developed after consultation with affected agencies and after such public hearings as may be appropriate. They will be designed to make the environmental impact statement process more useful to decisionmakers and the public; and to reduce paperwork and the accumulation of extraneous background data, in order to emphasize the need to focus on real environmental issues and alternatives. They will require impact statements to be concise, clear, and to the point, and supported by evidence that agencies have made the necessary environmental analyses. The Council shall include in its regulations procedures (1) for the early preparation of environmental impact statements, and (2) for the referral to the Council of conflicts between agencies concerning the implementation of the National Environmental Policy Act of 1969, as amended, and Section 309 of the Clean Air Act, as amended, for the Council's recommendation as to their prompt resolution.

(i) Issue such other instructions to agencies, and request such reports and other information from them, as may be required to carry out the Council's responsibilities under the Act.

(j) Assist the President in preparing the annual Environmental Quality Report provided for in section 201 of the Act.

(k) Foster investigations, studies, surveys, research, and analyses relating to (i) ecological systems and environmental quality, (ii) the impact of new and changing technologies thereon, and (iii) means of preventing or reducing adverse effects from such technologies.

Section 4. *Amendments of E.O. 11472.* Executive Order No. 11472 of May 29, 1969, including the heading thereof, is hereby amended:

(1) By substituting for the term "the Environmental Quality Council", wherever it occurs, the following: "the Cabinet Committee on the Environment".

(2) By substituting for the term "the Council", wherever it occurs, the following: "the Cabinet Committee".

(3) By inserting in subsection (f) of section 101, after "Budget,", the following: "the Director of the Office of Science and Technology,".

(4) By substituting for subsection (g) of section 101 the following:

"(g) The Chairman of the Council on Environmental Quality (established by Public Law 91–190) shall assist the President in directing the affairs of the Cabinet Committee."

(5) By deleting subsection (c) of section 102.

(6) By substituting for "the Office of Science and Technology", in section 104, the following: "the Council on Environmental Quality (established by Public Law 91–190)".

(7) By substituting for "(hereinafter referred to as the 'Committee')", in section 201, the following: "(hereinafter referred to as the 'Citizens' Committee')".

(8) By substituting for the term "the Committee", wherever it occurs, the following: "the Citizens' Committee".

APPENDIX E

REGULATIONS FOR IMPLEMENTING THE PROCEDURAL PROVISIONS OF NEPA

The Council on Environmental Quality is responsible for overseeing Federal efforts to comply with the National Environmental Policy Act (NEPA). In 1970, the Council issued guidelines for the preparation of environmental impact statements (EISs) under Executive Order 11514 (1970). By the terms of the Executive Order, the Guidelines were confined to Subsection (C) of Section 102(2) of NEPA—the requirement for environmental impact statements.

On May 24, 1977, President Carter issued Executive Order 11991 directing the Council to issue regulations to replace the Guidelines for preparation of EISs and to implement other provisions for agency planning and decisionmaking contained in Section 102(2) of the Act. These new regulations, 40 CFR Parts 1500–1508, reprinted below, were promulgated on November 29, 1978 and became effective July 30, 1979.

The new regulations have three principal aims: to reduce paperwork, to reduce delays, and to produce better decisions.

In accordance with the President's directive, the Council's regulations are binding on all Federal agencies, replace some 70 different sets of agency regulations, and provide uniform standards applicable throughout the Federal government for conducting environmental reviews. The regulations also establish formal guidance from the Council on the requirements of NEPA for use by the courts in interpreting this law.

PART 1500—PURPOSE, POLICY, AND MANDATE

1500.1 Purpose
1500.2 Policy
1500.3 Mandate
1500.4 Reducing paperwork
1500.5 Reducing delay
1500.6 Agency authority

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), section 309 of the Clean Air Act, as amended (42 U.S.C. 7609) and Executive Order 11514, Protection and Enhancement of Environmental Quality (March 5, 1970 as amended by Executive Order 11991, May 24, 1977).

§ 1500.1 PURPOSE

(a) The National Environmental Policy Act (NEPA) is our basic national charter for protection of the environment. It establishes policy, sets goals (section 101), and provides means (section 102) for carrying out the policy.

Section 102(2) contains "action-forcing" provisions to make sure that federal agencies act according to the letter and spirit of the Act. The regulations that follow implement Section 102(2). Their purpose is to tell federal agencies what they must do to comply with the procedures and achieve the goals of the Act. The President, the federal agencies, and the courts share responsibility for enforcing the Act so as to achieve the substantive requirements of section 101.

(b) NEPA procedures must insure that environmental information is available to public officials and citizens before decisions are made and before actions are taken. The information must be of high quality. Accurate scientific analysis, expert agency comments, and public scrutiny are essential to implementing NEPA. Most important, NEPA documents must concentrate on the issues that are truly significant to the action in question, rather than amassing needless detail.

(c) Ultimately, of course, it is not better documents but better decisions that count. NEPA's purpose is not to generate paperwork—even excellent paperwork—but to foster excellent action. The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment. These regulations provide the direction to achieve this purpose.

§ 1500.2 POLICY

Federal agencies shall to the fullest extent possible:

(a) Interpret and administer the policies, regulations, and public laws of the United States in accordance with the policies set forth in the Act and in these regulations.

(b) Implement procedures to make the NEPA process more useful to decisionmakers and the public; to reduce paperwork and the accumulation of extraneous background data; and to emphasize real environmental issues and alternatives. Environmental impact statements shall be concise, clear, and to the point, and shall be supported by evidence that agencies have made the necessary environmental analyses.

(c) Integrate the requirements of NEPA with other planning and environmental review procedures required by law or by agency practice so that all such procedures run concurrently rather than consecutively.

(d) Encourage and facilitate public involvement in decisions which affect the quality of the human environment.

(e) Use the NEPA process to identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions upon the quality of the human environment.

(f) Use all practicable means, consistent with the requirements of the Act and other essential considerations of national policy, to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects of their actions upon the quality of the human environment.

§ 1500.3 MANDATE

Parts 1500–1508 of this Title provide regulations applicable to and binding on all Federal agencies for implementing the procedural provisions of the National Environmental Policy Act of 1969, as amended (Pub. L. 91–190, 42 U.S.C. 4321 et seq.) (NEPA or the Act) except where compliance would be inconsistent with other statutory requirements. These regulations are issued pursuant to NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.) Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609) and Executive Order 11514, Protection and Enhancement of Environmental Quality (March 5, 1970, as amended by

Executive Order 11991, May 24, 1977). These regulations, unlike the predecessor guidelines, are not confined to Sec. 102(2)(C) (environmental impact statements). The regulations apply to the whole of section 102(2). The provisions of the Act and of these regulations must be read together as a whole in order to comply with the spirit and letter of the law. It is the Council's intention that judicial review of agency compliance with these regulations not occur before an agency has filed the final environmental impact statement, or has made a final finding of no significant impact (when such a finding will result in action affecting the environment), or takes action that will result in irreparable injury. Furthermore, it is the Council's intention that any trivial violation of these regulations not give rise to any independent cause of action.

§ 1500.4 REDUCING PAPERWORK

Agencies shall reduce excessive paperwork by:

(a) Reducing the length of environmental impact statements (§ 1502.2(c)), by means such as setting appropriate page limits (§§ 1501.7(b)(1) and 1502.7).

(b) Preparing analytic rather than encyclopedic environmental impact statements (§ 1502.2(a)).

(c) Discussing only briefly issues other than significant ones (§ 1502.2(b)).

(d) Writing environmental impact statements in plain language (§ 1502.8).

(e) Following a clear format for environmental impact statements (§ 1502.10).

(f) Emphasizing the portions of the environmental impact statement that are useful to decisionmakers and the public (§§ 1502.14 and 1502.15) and reducing emphasis on background material (§ 1502.16).

(g) Using the scoping process, not only to identify significant environmental issues deserving of study, but also to deemphasize insignificant issues, narrowing the scope of the environmental impact statement process accordingly (§ 1501.7).

(h) Summarizing the environmental impact statement (§ 1502.12) and circulating the summary instead of the entire environmental impact statement if the latter is unusually long (§ 1502.19).

(i) Using program, policy, or plan environmental impact statements and tiering from statements of broad scope to those of narrower scope, to eliminate repetitive discussions of the same issues (§§ 1502.4 and 1502.20).

(j) Incorporating by reference (§ 1502.21).

(k) Integrating NEPA requirements with other environmental review and consultation requirements (§ 1502.25).

(l) Requiring comments to be as specific as possible (§ 1503.3).

(m) Attaching and circulating only changes to the draft environmental impact statement, rather than rewriting and circulating the entire statement when changes are minor (§ 1503.4(c)).

(n) Eliminating duplication with State and local procedures, by providing for joint preparation (§ 1506.2), and with other Federal procedures, by providing that an agency may adopt appropriate environmental documents prepared by another agency (§ 1506.3).

(o) Combining environmental documents with other documents (§ 1506.4).

(p) Using categorical exclusions to define categories of actions which do not individually or cumulatively have a significant effect on the human environment and which are therefore exempt from requirements to prepare an environmental impact statement (§ 1508.4).

(q) Using a finding of no significant impact when an action not otherwise excluded will not have a significant effect on the human environment and is therefore exempt from requirements to prepare an environmental impact statement (§ 1508.13).

§ 1500.5 REDUCING DELAY

Agencies shall reduce delay by:

(a) Integrating the NEPA process into early planning (§ 1501.2).

(b) Emphasizing interagency cooperation before the environmental impact statement is prepared, rather than submission of adversary comments on a completed document (§ 1501.6).

(c) Insuring the swift and fair resolution of lead agency disputes (§ 1501.5).

(d) Using the scoping process for an early identification of what are and what are not the real issues (§ 1501.7).

(e) Establishing appropriate time limits for the environmental impact statement process (§§ 1501.7(b)(2) and 1501.8).

(f) Preparing environmental impact statements early in the process (§ 1502.5).

(g) Integrating NEPA requirements with other environmental review and consultation requirements (§ 1502.25).

(h) Eliminating duplication with State and local procedures by providing for joint preparation (§ 1506.2) and with other Federal procedures by providing that an agency may adopt appropriate environmental documents prepared by another agency (§ 1506.3).

(i) Combining environmental documents with other documents (§ 1506.4).

(j) Using accelerated procedures for proposals for legislation (§ 1506.8).

(k) Using categorical exclusions to define categories of actions which do not individually or cumulatively have a significant effect on the human environment (§ 1508.4) and which are therefore exempt from requirements to prepare an environmental impact statement.

(l) Using a finding of no significant impact when an action not otherwise excluded will not have a significant effect on the human environment (§ 1508.13) and is therefore exempt from requirements to prepare an environmental impact statement.

§ 1500.6 AGENCY AUTHORITY

Each agency shall interpret the provisions of the Act as a supplement to its existing authority and as a mandate to view traditional policies and missions in the light of the Act's national environmental objectives. Agencies shall review their policies, procedures, and regulations accordingly and revise them as necessary to insure full compliance with the purposes and provisions of the Act. The phrase "to the fullest extent possible" in section 102 means that each agency of the Federal Government shall comply with that section unless existing law applicable to the agency's operations expressly prohibits or makes compliance impossible.

PART 1501—NEPA AND AGENCY PLANNING

1501.1 Purpose
1501.2 Apply NEPA early in the process
1501.3 When to prepare an environmental assessment
1501.4 Whether to prepare an environmental impact statement
1501.5 Lead agencies
1501.6 Cooperating agencies
1501.7 Scoping
1501.8 Time limits

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and Executive Order 11514, Protection and En-

hancement of Environmental Quality (March 5, 1970, as amended by Executive Order 11991, May 24, 1977).

§ 1501.1 PURPOSE

The purposes of this part include:

(a) Integrating the NEPA process into early planning to insure appropriate consideration of NEPA's policies and to eliminate delay.

(b) Emphasizing cooperative consultation among agencies before the environmental impact statement is prepared rather than submission of adversary comments on a completed document.

(c) Providing for the swift and fair resolution of lead agency disputes.

(d) Identifying at an early stage the significant environmental issues deserving of study and deemphasizing insignificant issues, narrowing the scope of the environmental impact statement accordingly.

(e) Providing a mechanism for putting appropriate time limits on the environmental impact statement process.

§ 1501.2 APPLY NEPA EARLY IN THE PROCESS

Agencies shall integrate the NEPA process with other planning at the earliest possible time to insure that planning and decisions reflect environmental values, to avoid delays later in the process, and to head off potential conflicts. Each agency shall:

(a) Comply with the mandate of section 102(2)(A) to "utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment," as specified by § 1507.2.

(b) Identify environmental effects and values in adequate detail so they can be compared to economic and technical analyses. Environmental documents and appropriate analyses shall be circulated and reviewed at the same time as other planning documents.

(c) Study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources as provided by section 102(2)(E) of the Act.

(d) Provide for cases where actions are planned by private applicants or other non-Federal entities before Federal involvement so that:

(1) Policies or designated staff are available to advise potential applicants of studies or other information foreseeably required for later Federal action.

(2) The Federal agency consults early with appropriate State and local agencies and Indian tribes and with interested private persons and organizations when its own involvement is reasonably foreseeable.

(3) The Federal agency commences its NEPA process at the earliest possible time.

§ 1501.3 WHEN TO PREPARE AN ENVIRONMENTAL ASSESSMENT

(a) Agencies shall prepare an environmental assessment (§ 1508.9) when necessary under the procedures adopted by individual agencies to supplement these regulations as described in § 1507.3. An assessment is not necessary if the agency has decided to prepare an environmental impact statement.

(b) Agencies may prepare an environmental assessment on any action at any time in order to assist agency planning and decisionmaking.

§ 1501.4 WHETHER TO PREPARE AN ENVIRONMENTAL IMPACT STATEMENT

In determining whether to prepare an environmental impact statement the Federal agency shall:

(a) Determine under its procedures supplementing these regulations (described in § 1507.3) whether the proposal is one which:

(1) Normally requires an environmental impact statement, or

(2) Normally does not require either an environmental impact statement or an environmental assessment (categorical exclusion).

(b) If the proposed action is not covered by paragraph (a) of this section, prepare an environmental assessment (§ 1508.9). The agency shall involve environmental agencies, applicants, and the public, to the extent practicable, in preparing assessments required by § 1508.9(a)(1).

(c) Based on the environmental assessment make its determination whether to prepare an environmental impact statement.

(d) Commence the scoping process (§ 1501.7), if the agency will prepare an environmental impact statement.

(e) Prepare a finding of no significant impact (§ 1508.13), if the agency determines on the basis of the environmental assessment not to prepare a statement.

(1) The agency shall make the finding of no significant impact available to the affected public as specified in § 1506.6.

(2) In certain limited circumstances, which the agency may cover in its procedures under § 1507.3, the agency shall make the finding of no its procedures under § 1507.3, the agency shall make the finding of no significant impact available for public review (including State and area-wide clearinghouses) for 30 days before the agency makes its final determination whether to prepare an environmental impact statement and before the action may begin. The circumstances are:

(i) The proposed action is, or is closely similar to, one which normally requires the preparation of an environmental impact statement under the procedures adopted by the agency pursuant to § 1507.3, or

(ii) The nature of the proposed action is one without precedent.

§ 1501.5 LEAD AGENCIES

(a) A lead agency shall supervise the preparation of an environmental impact statement if more than one Federal agency either:

(1) Proposes or is involved in the same action; or

(2) Is involved in a group of actions directly related to each other because of their functional interdependence or geographical proximity.

(b) Federal, State, or local agencies, including at least one Federal agency, may act as joint lead agencies to prepare an environmental impact statement (§ 1506.2).

(c) If an action falls within the provisions of paragraph (a) of this section the potential lead agencies shall determine by letter or memorandum which agency shall be the lead agency and which shall be cooperating agencies. The agencies shall resolve the lead agency question so as not to cause delay. If there is disagreement among the agencies, the following factors (which are listed in order of descending importance) shall determine lead agency designation:

(1) Magnitude of agency's involvement.

(2) Project approval/disapproval authority.

(3) Expertise concerning the action's environmental effects.

(4) Duration of agency's involvement.

(5) Sequence of agency's involvement.

(d) Any Federal agency, or any State or local agency or private person substantially affected by the absence of lead agency designation, may make a written request to the potential lead agencies that a lead agency be designated.

(e) If Federal agencies are unable to agree on which agency will be the lead agency or if the procedure described in paragraph (c) of this section

has not resulted within 45 days in a lead agency designation, any of the agencies or persons concerned may file a request with the Council asking it to determine which Federal agency shall be the lead agency.

A copy of the request shall be transmitted to each potential lead agency. The request shall consist of:

(1) A precise description of the nature and extent of the proposed action.

(2) A detailed statement of why each potential lead agency should or should not be the lead agency under the criteria specified in paragraph (c) of this section.

(f) A response may be filed by any potential lead agency concerned within 20 days after a request is filed with the Council. The Council shall determine as soon as possible but not later than 20 days after receiving the request and all responses to it which Federal agency shall be the lead agency and which other Federal agencies shall be cooperating agencies.

§ 1501.6 COOPERATING AGENCIES

The purpose of this section is to emphasize agency cooperation early in the NEPA process. Upon request of the lead agency, any other Federal agency which has jurisdiction by law shall be a cooperating agency. In addition any other Federal agency which has special expertise with respect to any environmental issue, which should be addressed in the statement may be a cooperating agency upon request of the lead agency. An agency may request the lead agency to designate it a cooperating agency.

(a) The lead agency shall:

(1) Request the participation of each cooperating agency in the NEPA process at the earliest possible time.

(2) Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible consistent with its responsibility as lead agency.

(3) Meet with a cooperating agency at the latter's request.

(b) Each cooperating agency shall:

(1) Participate in the NEPA process at the earliest possible time.

(2) Participate in the scoping process (described below in § 1501.7).

(3) Assume on request of the lead agency responsibility for developing information and preparing environmental analyses including portions of the environmental impact statement concerning which the cooperating agency has special expertise.

(4) Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.

(5) Normally use its own funds. The lead agency shall, to the extent available funds permit, fund those major activities or analyses it requests from cooperating agencies. Potential lead agencies shall include such funding requirements in their budget requests.

(c) A cooperating agency may in response to a lead agency's request for assistance in preparing the environmental impact statement (described in paragraph (b) (3), (4), or (5) of this section) reply that other program commitments preclude any involvement or the degree of involvement requested in the action that is the subject of the environmental impact statement. A copy of this reply shall be submitted to the Council.

§ 1501.7 SCOPING

There shall be an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. This process shall be termed scoping. As soon as practicable after its decision to prepare an environmental impact statement and before

the scoping process the lead agency shall publish a notice of intent (§ 1508.22) in the Federal Register except as provided in § 1507.3(e).

(a) As part of the scoping process the lead agency shall:

(1) Invite the participation of affected Federal, State, and local agencies, any affected Indian tribe, the proponent of the action, and other interested persons (including those who might not be in accord with the action on environmental grounds), unless there is a limited exception under § 1507.3(c). An agency may give notice in accordance with § 1506.6.

(2) Determine the scope (§ 1508.25) and the significant issues to be analyzed in depth in the environmental impact statement.

(3) Identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review (§ 1506.3), narrowing the discussion of these issues in the statement to a brief presentation of why they will not have a significant effect on the human environment or providing a reference to their coverage elsewhere.

(4) Allocate assignments for preparation of the environmental impact statement among the lead and cooperating agencies, with the lead agency retaining responsibility for the statement.

(5) Indicate any public environmental assessments and other environmental impact statements which are being or will be prepared that are related to but are not part of the scope of the impact statement under consideration.

(6) Identify other environmental review and consultation requirements so the lead and cooperating agencies may prepare other required analyses and studies concurrently with, and integrated with, the environmental impact statement as provided in § 1502.25.

(7) Indicate the relationship between the timing of the preparation of environmental analyses and the agency's tentative planning and decision-making schedule.

(b) As part of the scoping process the lead agency may:

(1) Set page limits on environmental documents (§ 1502.7).

(2) Set time limits (§ 1501.8).

(3) Adopt procedures under § 1507.3 to combine its environmental assessment process with its scoping process.

(4) Hold an early scoping meeting or meetings which may be integrated with any other early planning meeting the agency has. Such a scoping meeting will often be appropriate when the impacts of a particular action are confined to specific sites.

(c) An agency shall revise the determinations made under paragraphs (a) and (b) of this section if substantial changes are made later in the proposed action, or if significant new circumstances or information arise which bear on the proposal or its impacts.

§ 1501.8 TIME LIMITS

Although the Council has decided that prescribed universal time limits for the entire NEPA process are too inflexible, Federal agencies are encouraged to set time limits appropriate to individual actions (consistent with the time intervals required by § 1506.10). When multiple agencies are involved the reference to agency below means lead agency.

(a) The agency shall set time limits if an applicant for the proposed action requests them: *Provided,* That the limits are consistent with the purposes of NEPA and other essential considerations of national policy.

(b) The agency may:

(1) Consider the following factors in determining time limits:

(i) Potential for environmental harm.

(ii) Size of the proposed action.

(iii) State of the art of analytic techniques.

(iv) Degree of public need for the proposed action, including the consequences of delay.

(v) Number of persons and agencies affected.

(vi) Degree to which relevant information is known and if not known the time required for obtaining it.

(vii) Degree to which the action is controversial.

(viii) Other time limits imposed on the agency by law, regulations, or executive order.

(2) Set overall time limits or limits for each constituent part of the NEPA process, which may include:

(i) Decision on whether to prepare an environmental impact statement (if not already decided).

(ii) Determination of the scope of the environmental impact statement.

(iii) Preparation of the draft environmental impact statement.

(iv) Review of any comments on the draft environmental impact statement from the public and agencies.

(v) Preparation of the final environmental impact statement.

(vi) Review of any comments on the final environmental impact statement.

(vii) Decision on the action based in part on the environmental impact statement.

(3) Designate a person (such as the project manager or a person in the agency's office with NEPA responsibilities) to expedite the NEPA process.

(c) State or local agencies or members of the public may request a Federal Agency to set time limits.

PART 1502—ENVIRONMENTAL IMPACT STATEMENT

1502.1 Purpose
1502.2 Implementation
1502.3 Statutory Requirements for Statements
1502.4 Major Federal Actions Requiring the Preparation of Environmental Impact Statements
1502.5 Timing
1502.6 Interdisciplinary Preparation
1502.7 Page Limits
1502.8 Writing
1502.9 Draft, Final, and Supplemental Statements
1502.10 Recommended Format
1502.11 Cover Sheet
1502.12 Summary
1502.13 Purpose and Need
1502.14 Alternatives Including the Proposed Action
1502.15 Affected Environment
1502.16 Environmental Consequences
1502.17 List of Preparers
1502.18 Appendix
1502.19 Circulation of the Environmental Impact Statement
1502.20 Tiering
1502.21 Incorporation by Reference
1502.22 Incomplete or Unavailable Information
1502.23 Cost-Benefit Analysis
1502.24 Methodology and Scientific Accuracy
1502.25 Environmental Review and Consultation Requirements

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and Executive Order 11514, Protection and En-

hancement of Environmental Quality (March 5, 1970, as amended by Executive Order 11991, May 24, 1977).

§ 1502.1 PURPOSE

The primary purpose of an environmental impact statement is to serve as an action-forcing device to insure that the policies and goals defined in the Act are infused into the ongoing programs and actions of the Federal Government. It shall provide full and fair discussion of significant environmental impacts and shall inform decisionmakers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment. Agencies shall focus on significant environmental issues and alternatives and shall reduce paperwork and the accumulation of extraneous background data. Statements shall be concise, clear, and to the point, and shall be supported by evidence that the agency has made the necessary environmental analyses. An environmental impact statement is more than a disclosure document. It shall be used by Federal officials in conjunction with other relevant material to plan actions and make decisions.

§ 1502.2 IMPLEMENTATION

To achieve the purposes set forth in § 1502.1 agencies shall prepare environmental impact statements in the following manner:

(a) Environmental impact statements shall be analytic rather than encyclopedic.

(b) Impacts shall be discussed in proportion to their significance. There shall be only brief discussion of other than significant issues. As in a finding of no significant impact, there should be only enough discussion to show why more study is not warranted.

(c) Environmental impact statements shall be kept concise and shall be no longer than absolutely necessary to comply with NEPA and with these regulations. Length should vary first with potential environmental problems and then with project size.

(d) Environmental impact statements shall state how alternatives considered in it and decisions based on it will or will not achieve the requirements of sections 101 and 102(1) of the Act and other environmental laws and policies.

(e) The range of alternatives discussed in environmental impact statements shall encompass those to be considered by the ultimate agency decisionmaker.

(f) Agencies shall not commit resources prejudicing selection of alternatives before making a final decision (§ 1506.1).

(g) Environmental impact statements shall serve as the means of assessing the environmental impact of proposed agency actions, rather than justifying decisions already made.

§ 1502.3 STATUTORY REQUIREMENTS FOR STATEMENTS

As required by sec. 102(2)(C) of NEPA environmental impact statements (§ 1508.11) are to be included in every recommendation or report
On proposals (§ 1508.23)
For legislation and (§ 1508.17)
Other major Federal actions (§ 1508.18)
Significantly (§ 1508.27)
Affecting (§§ 1508.3, 1508.8)
The quality of the human environment (§ 1508.14).

§ 1502.4 MAJOR FEDERAL ACTIONS REQUIRING THE PREPARATION OF ENVIRONMENTAL IMPACT STATEMENTS

(a) Agencies shall make sure the proposal which is the subject of an environmental impact statement is properly defined. Agencies shall use the criteria for scope (§ 1508.25) to determine which proposal(s) shall be the

subject of a particular statement. Proposals or parts of proposals which are related to each other closely enough to be, in effect, a single course of action shall be evaluated in a single impact statement.

(b) Environmental impact statements may be prepared, and are sometimes required, for broad Federal actions such as the adoption of new agency programs or regulations (§ 1508.18). Agencies shall prepare statements on broad actions so that they are relevant to policy and are timed to coincide with meaningful points in agency planning and decisionmaking.

(c) When preparing statements on broad actions (including proposals by more than one agency), agencies may find it useful to evaluate the proposal(s) in one of the following ways:

(1) Geographically, including actions occurring in the same general location, such as body of water, region, or metropolitan area.

(2) Generically, including actions which have relevant similarities, such as common timing, impacts, alternatives, methods of implementation, media, or subject matter.

(3) By stage of technological development including federal or federally assisted research, development or demonstration programs for new technologies which, if applied, could significantly affect the quality of the human environment. Statements shall be prepared on such programs and shall be available before the program has reached a stage of investment or commitment to implementation likely to determine subsequent development or restrict later alternatives.

(d) Agencies shall as appropriate employ scoping (§ 1501.7), tiering (§ 1502.20), and other methods listed in §§ 1500.4 and 1500.5 to relate broad and narrow actions and to avoid duplication and delay.

§ 1502.5 TIMING

An agency shall commence preparation of an environmental impact statement as close as possible to the time the agency is developing or is presented with a proposal (§ 1508.23) so that preparation can be completed in time for the final statement to be included in any recommendation or report on the proposal. The statement shall be prepared early enough so that it can serve practically as an important contribution to the decisionmaking process and will not be used to rationalize or justify decisions already made (§§ 1500.2(c), 1501.2, and 1502.2). For instance:

(a) For projects directly undertaken by Federal agencies the environmental impact statement shall be prepared at the feasibility analysis (go-no go) stage and may be supplemented at a later stage if necessary.

(b) For applications to the agency appropriate environmental assessments or statements shall be commenced no later than immediately after the application is received. Federal agencies are encouraged to begin preparation of such assessments or statements earlier, preferably jointly with applicable State or local agencies.

(c) For adjudication, the final environmental impact statement shall normally precede the final staff recommendation and that portion of the public hearing related to the impact study. In appropriate cirmumstances the statement may follow preliminary hearings designed to gather information for use in the statements.

(d) For informal rulemaking the draft environmental impact statement shall normally accompany the proposed rule.

§ 1502.6 INTERDISCIPLINARY PREPARATION

Environmental impact statements shall be prepared using an interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts (section 102(2)(A) of the Act). The disciplines of the preparers shall be appropriate to the scope and issues identified in the scoping process (§ 1501.7).

§ 1502.7 PAGE LIMITS

The text of final environmental impact statements (e.g., paragraphs (d) through (g) of § 1502.10) shall normally be less than 150 pages and for proposals of unusual scope or complexity shall normally be less than 300 pages.

§ 1502.8 WRITING

Environmental impact statements shall be written in plain language and may use appropriate graphics so that decisionmakers and the public can readily understand them. Agencies should employ writers of clear prose or editors to write, review, or edit statements, which will be based upon the analysis and supporting data from the natural and social sciences and the environmental design arts.

§ 1502.9 DRAFT, FINAL, AND SUPPLEMENTAL STATEMENTS

Except for proposals for legislation as provided in § 1506.8 environmental impact statements shall be prepared in two stages and may be supplemented.

(a) Draft environmental impact statements shall be prepared in accordance with the scope decided upon in the scoping process. The lead agency shall work with the cooperating agencies and shall obtain comments as required in Part 1503 of this chapter. The draft statement must fulfill and satisfy to the fullest extent possible the requirements established for final statements in section 102(2)(C) of the Act. If a draft statement is so inadequate as to preclude meaningful analysis, the agency shall prepare and circulate a revised draft of the appropriate portion. The agency shall make every effort to disclose and discuss at appropriate points in the draft statement all major points of view on the environmental impacts of the alternatives including the proposed action.

(b) Final environmental impact statements shall respond to comments as required in Part 1503 of this chapter. The agency shall discuss at appropriate points in the final statement any responsible opposing view which was not adequately discussed in the draft statement and shall indicate the agency's response to the issues raised.

(c) Agencies:

(1) Shall prepare supplements to either draft or final environmental impact statements if:

(i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns; or

(ii) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.

(2) May also prepare supplements when the agency determines that the purposes of the Act will be furthered by doing so.

(3) Shall adopt procedures for introducing a supplement into its formal administrative record, if such a record exists.

(4) Shall prepare, circulate, and file a supplement to a statement in the same fashion (exclusive of scoping) as a draft and final statement unless alternative procedures are approved by the Council.

§ 1502.10 RECOMMENDED FORMAT

Agencies shall use a format for environmental impact statements which will encourage good analysis and clear presentation of the alternatives including the proposed action. The following standard format for environmental impact statements should be followed unless the agency determines that there is a compelling reason to do otherwise:

(a) Cover sheet.

(b) Summary.

(c) Table of Contents.

(d) Purpose of and Need for Action.
(e) Alternatives Including Proposed Action (secs. 102(2)(C)(iii) and 102(2)(E) of the Act).
(f) Affected Environment.
(g) Environmental Consequences (especially sections 102(2)(C) (i), (ii), (iv), and (v) of the Act).
(h) List of Preparers.
(i) List of Agencies, Organizations, and Persons to Whom Copies of the Statement Are Sent.
(j) Index.
(k) Appendices (if any).

If a different format is used, it shall include paragraphs (a), (b), (c), (h), (i), and (j), of this section and shall include the substance of paragraphs (d), (e), (f), (g), and (k) of this section, as further described in §§ 1502.11–1502.18, in any appropriate format.

§ 1502.11 COVER SHEET

The cover sheet shall not exceed one page. It shall include:
(a) A list of the responsible agencies including the lead agency and any cooperating agencies.
(b) The title of the proposed action that is the subject of the statement (and if appropriate the titles of related cooperating agency actions), together with the State(s) and county(ies) (or other jurisdiction if applicable) where the action is located.
(c) The name, address, and telephone number of the person at the agency who can supply further information.
(d) A designation of the statement as a draft, final, or draft or final supplement.
(e) A one paragraph abstract of the statement.
(f) The date by which comments must be received (computed in cooperation with EPA under § 1506.10).
The information required by this section may be entered on Standard Form 424 (in items 4, 6, 7, 10, and 18).

§ 1502.12 SUMMARY

Each environmental impact statement shall contain a summary which adequately and accurately summarizes the statement. The summary shall stress the major conclusions, areas of controversy (including issues raised by agencies and the public), and the issues to be resolved (including the choice among alternatives). The summary will normally not exceed 15 pages.

§ 1502.13 PURPOSE AND NEED

The statement shall briefly specify the underlying purpose and need to which the agency is responding in proposing the alternatives including the proposed action.

§ 1502.14 ALTERNATIVES INCLUDING THE PROPOSED ACTION

This section in the heart of the environmental impact statement. Based on the information and analysis presented in the sections on the Affected Environment (§ 1502.15) and the Environmental Consequences (§ 1502.16), it should present the environmental impacts of the proposal and the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decisionmaker and the public. In this section agencies shall:
(a) Rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated.

(b) Devote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits.

(c) Include reasonable alternatives not within the jurisdiction of the lead agency.

(d) Include the alternative of no action.

(e) Identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such a preference.

(f) Include appropriate mitigation measures not already included in the proposed action or alternatives.

§ 1502.15 AFFECTED ENVIRONMENT

The environmental impact statement shall succinctly describe the environment of the area(s) to be affected or created by the alternatives under consideration. The descriptions shall be no longer than is necessary to understand the effects of the alternatives. Data and analyses in a statement shall be commensurate with the importance of the impact, with less important material summarized, consolidated, or simply referenced. Agencies shall avoid useless bulk in statements and shall concentrate effort and attention on important issues. Verbose descriptions of the affected environment are themselves no measure of the adequacy of an environmental impact statement.

§ 1502.16 ENVIRONMENTAL CONSEQUENCES

This section forms the scientific and analytic basis for the comparisons under § 1502.14. It shall consolidate the discussions of those elements required by secs. 102(2)(C) (i), (ii), (iv), and (v) of NEPA which are within the scope of the statement and as much of sec. 102(2)(C)(iii) as is necessary to support the comparisons. The discussion will include the environmental impacts of the alternatives including the proposed action, any adverse environmental effects which cannot be avoided should the proposal be implemented, the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented. This section should not duplicate discussions in § 1502.14. It shall include discussions of:

(a) Direct effects and their significance (§ 1508.8).

(b) Indirect effects and their significance (§ 1508.8).

(c) Possible conflicts between the proposed action and the objectives of Federal, regional, State, and local (and in the case of a reservation, Indian tribe) land use plans, policies and controls for the area concerned. (See § 1506.2(d).)

(d) The environmental effects of alternatives including the proposed action. The comparisons under § 1502.14 will be based on this discussion.

(e) Energy requirements and conservation potential of various alternatives and mitigation measures.

(f) Natural or depletable resource requirements and conservation potential of various alternatives and mitigation measures.

(g) Urban quality, historic and cultural resources, and the design of the built environment, including the reuse and conservation potential of various alternatives and mitigation measures.

(h) Means to mitigate adverse environmental impacts (if not fully covered under § 1502.14(f)).

§ 1502.17 LIST OF PREPARERS

The environmental impact statement shall list the names, together with their qualifications (expertise, experience, professional disciplines), of the persons who were primarily responsible for preparing the environmental impact statement or significant background papers, including basic components

of the statement (§§ 1502.6 and 1502.8). Where possible the persons who are responsible for a particular analysis, including analyses in background papers, shall be identified. Normally the list will not exceed two pages.

§ 1502.18 APPENDIX

If an agency prepares an appendix to an environmental impact statement the appendix shall:

(a) Consist of material prepared in connection with an environmental impact statement (as distinct from material which is not so prepared and which is incorporated by reference (§ 1502.21)).

(b) Normally consist of material which substantiates any analysis fundamental to the impact statement.

(c) Normally be analytic and relevant to the decision to be made.

(d) Be circulated with the environmental impact statement or be readily available on request.

§ 1502.19 CIRCULATION OF THE ENVIRONMENTAL IMPACT STATEMENT

Agencies shall circulate the entire draft and final environmental impact statements except for certain appendices as provided in § 1502.18(d) and unchanged statements as provided in § 1503.4(c). However, if the statement is unusually long, the agency may circulate the summary instead, except that the entire statement shall be furnished to:

(a) Any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved and any appropriate Federal, State or local agency authorized to develop and enforce environmental standards.

(b) The applicant, if any.

(c) Any person, organization, or agency requesting the entire environmental impact statement.

(d) In the case of a final environmental impact statement any person, organization, or agency which submitted substantive comments on the draft.

If the agency circulates the summary and thereafter receives a timely request for the entire statement and for additional time to comment, the time for that requestor only shall be extended by at least 15 days beyond the minimum period.

§ 1502.20 TIERING

Agencies are encouraged to tier their environmental impact statements to eliminate repetitive discussions of the same issues and to focus on the actual issues ripe for decision at each level of environmental review (§ 1508.28). Whenever a broad environmental impact statement has been prepared (such as a program or policy statement) and a subsequent statement or environmental assessment is then prepared on an action included within the entire program or policy (such as a site-specific action) the subsequent statement or environmental assessment need only summarize the issues discussed in the broader statement and incorporate discussions from the broader statement by reference and shall concentrate on the issues specific to the subsequent action. The subsequent document shall state where the earlier document is available. Tiering may also be appropriate for different stages of actions. (Sec. 1508.28).

§ 1502.21 INCORPORATION BY REFERENCE

Agencies shall incorporate material into an environmental impact statement by reference when the effect will be to cut down on bulk without impeding agency and public review of the action. The incorporated material shall be cited in the statement and its content briefly described. No material may be incorporated by reference unless it is reasonably available for inspec-

tion by potentially interested persons within the time allowed for comment. Material based on proprietary data which is itself not available for review and comment shall not be incorporated by reference.

§ 1502.22 INCOMPLETE OR UNAVAILABLE INFORMATION

When an agency is evaluating significant adverse effects on the human environment in an environmental impact statement and there are gaps in relevant information or scientific uncertainty, the agency shall always make clear that such information is lacking or that uncertainty exists.

(a) If the information relevant to adverse impacts is essential to a reasoned choice among alternatives and is not known and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement.

(b) If (1) the information relevant to adverse impacts is essential to a reasoned choice among alternatives and is not known and the overall costs of obtaining it are exorbitant or (2) the information relevant to adverse impacts is important to the decision and the means to obtain it are not known (e.g., the means for obtaining it are beyond the state of the art) the agency shall weigh the need for the action against the risk and severity of possible adverse impacts were the action to proceed in the face of uncertainty. If the agency proceeds, it shall include a worst case analysis and an indication of the probability or improbability of its occurrence.

§ 1502.23 COST-BENEFIT ANALYSIS

If a cost-benefit analysis relevant to the choice among environmentally different alternatives is being considered for the proposed action, it shall be incorporated by reference or appended to the statement as an aid in evaluating the environmental consequences. To assess the adequacy of compliance with sec. 102(2)(B) of the Act the statement shall, when a cost-benefit analysis is prepared, discuss the relationship between that analysis and any analyses of unquantified environmental impacts, values, and amenities. For purposes of complying with the Act, the weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary cost-benefit analysis and should not be when there are important qualitative considerations. In any event, an environmental impact statement should at least indicate those considerations, including factors not related to environmental quality, which are likely to be relevant and important to a decision.

§ 1502.24 METHODOLOGY AND SCIENTIFIC ACCURACY

Agencies shall insure the professional integrity, including scientific integrity, of the discussions and analyses in environmental impact statements. They shall identify any methodologies used and shall make explicit reference by footnote to the scientific and other sources relied upon for conclusions in the statement. An agency may place discussion of methodology in an appendix.

§ 1502.25 ENVIRONMENTAL REVIEW AND CONSULTATION REQUIREMENTS

(a) To the fullest extent possible, agencies shall prepare draft environmental impact statements concurrently with and integrated with environmental impact analyses and related surveys and studies required by the Fish and Wildlife Coordination Act (16 U.S.C. Sec. 661 et seq.), the National Historic Preservation Act of 1966 (16 U.S.C. Sec. 470 et seq.), the Endangered Species Act of 1973 (16 U.S.C. Sec 1531 et seq.), and other environmental review laws and executive orders.

(b) The draft environmental impact statement shall list all Federal permits, licenses, and other entitlements which must be obtained in implementing the proposal. If it is uncertain whether a Federal permit, license, or other entitlement is necessary, the draft environmental impact statement shall so indicate.

PART 1503—COMMENTING

1503.1 Inviting Comments
1503.2 Duty to Comment
1503.3 Specificity of Comments
1503.4 Response to Comments

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and Executive Order 11514, Protection and Enhancement of Environmental Quality (March 5, 1970, as amended by Executive Order 11991, May 24, 1977).

§ 1503.1 INVITING COMMENTS

(a) After preparing a draft environmental impact statement and before preparing a final environmental impact statement the agency shall:

(1) Obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved or which is authorized to develop and enforce environmental standards.

(2) Request the comments of:

(i) Appropriate State and local agencies which are authorized to develop and enforce environmental standards;

(ii) Indian tribes, when the effects may be on a reservation; and

(iii) Any agency which has requested that it receive statements on actions of the kind proposed.

Office of Management and Budget Circular A-95 (Revised), through its system of clearinghouses, provides a means of securing the views of State and local environmental agencies. The clearinghouses may be used, by mutual agreement of the lead agency and the clearinghouse, for securing State and local reviews of the draft environmental impact statements.

(3) Request comments from the applicant, if any.

(4) Request comments from the public, affirmatively soliciting comments from those persons or organizations who may be interested or affected.

(b) An agency may request comments on a final environmental impact statement before the decision is finally made. In any case other agencies or persons may make comments before the final decision unless a different time is provided under § 1506.10.

§ 1503.2 DUTY TO COMMENT

Federal agencies with jurisdiction by law or special expertise with respect to any environmental impact involved and agencies which are authorized to develop and enforce environmental standards shall comment on statements within their jurisdiction, expertise, or authority. Agencies shall comment within the time period specified for comment in § 1506.10. A Federal agency may reply that it has no comment. If a cooperating agency is satisfied that its views are adequately reflected in the environmental impact statement, it should reply that it has no comment.

§ 1503.3 SPECIFICITY OF COMMENTS

(a) Comments on an environmental impact statement or on a proposed action shall be as specific as possible and may address either the adequacy of the statement or the merits of the alternatives discussed or both.

(b) When a commenting agency criticizes a lead agency's predictive methodology, the commenting agency should describe the alternative methodology which it prefers and why.

(c) A cooperating agency shall specify in its comments whether it needs additional information to fulfill other applicable environmental reviews or consultation requirements and what information it needs. In particular, it shall specify any additional information it needs to comment adequately on the draft statement's analysis of significant site-specific effects associated with the granting or approving by that cooperating agency of necessary Federal permits, licenses, or entitlements.

(d) When a cooperating agency with jurisdiction by law objects to or expresses reservations about the proposal on grounds of environmental impacts, the agency expressing the objection or reservation shall specify the mitigation measures it considers necessary to allow the agency to grant or approve applicable permit, license, or related requirements or concurrences.

§ 1503.4 RESPONSE TO COMMENTS

(a) An agency preparing a final environmental impact statement shall assess and consider comments both individually and collectively, and shall respond by one or more of the means listed below, stating its response in the final statement. Possible responses are to:

(1) Modify alternatives including the proposed action.

(2) Develop and evaluate alternatives not previously given serious consideration by the agency.

(3) Supplement, improve, or modify its analyses.

(4) Make factual corrections.

(5) Explain why the comments do not warrant further agency response, citing the sources, authorities, or reasons which support the agency's position and, if appropriate, indicate those circumstances which would trigger agency reappraisal or further response.

(b) All substantive comments received on the draft statement (or summaries thereof where the response has been exceptionally voluminous), should be attached to the final statement whether or not the comment is thought to merit individual discussion by the agency in the text of the statement.

(c) If changes in response to comments are minor and are confined to the responses described in paragraphs (a) (4) and (5) of this section, agencies may write them on errata sheets and attach them to the statement instead of rewriting the draft statement. In such cases only the comments, the responses, and the changes and not the final statement need be circulated (§ 1502.19). The entire document with a new cover sheet shall be filed as the final statement (§ 1506.9).

PART 1504—PREDECISION REFERRALS TO THE COUNCIL OF PROPOSED FEDERAL ACTIONS DETERMINED TO BE ENVIRONMENTALLY UNSATISFACTORY

1504.1 Purpose
1504.2 Criteria for Referral
1504.3 Procedure for Referrals and Response

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and Executive Order 11514, Protection and Enhancement of Environmental Quality (March 5, 1970, as amended by Executive Order 11991, May 24, 1977).

§ 1504.1 PURPOSE

(a) This part establishes procedures for referring to the Council Federal interagency disagreements concerning proposed major Federal actions that might cause unsatisfactory environmental effects. It provides means for early resolution of such disagreements.

(b) Under section 309 of the Clean Air Act (42 U.S.C. 7609), the Administrator of the Environmental Protection Agency is directed to review and comment publicly on the environmental impacts of Federal activities, including actions for which environmental impact statements are prepared. If after this review the Administrator determines that the matter is "unsatisfactory from the standpoint of public health or welfare or environmental quality," section 309 directs that the matter be referred to the Council (hereafter "environmental referrals").

(c) Under section 102(2)(C) of the Act other Federal agencies may make similar reviews of environmental impact statements, including judgments on the acceptability of anticipated environmental impacts. These reviews must be made available to the President, the Council and the public.

§ 1504.2 CRITERIA FOR REFERRAL

Environmental referrals should be made to the Council only after concerted, timely (as early as possible in the process), but unsuccessful attempts to resolve differences with the lead agency. In determining what environmental objections to the matter are appropriate to refer to the Council, an agency should weigh potential adverse environmental impacts, considering:

(a) Possible violation of national environmental standards or policies.
(b) Severity.
(c) Geographical scope.
(d) Duration.
(e) Importance as precedents.
(f) Availability of environmentally preferable alternatives.

§ 1504.3 PROCEDURE FOR REFERRALS AND RESPONSE

(a) A Federal agency making the referral to the Council shall:

(1) Advise the lead agency at the earliest possible time that it intends to refer a matter to the Council unless a satisfactory agreement is reached.

(2) Include such advice in the referring agency's comments on the draft environmental impact statement, except when the statement does not contain adequate information to permit an assessment of the matter's environmental acceptability.

(3) Identify any essential information that is lacking and request that it be made available at the earliest possible time.

(4) Send copies of such advice to the Council.

(b) The referring agency shall deliver its referral to the Council not later than twenty-five (25) days after the final environmental impact statement has been made available to the Environmental Protection Agency, commenting agencies, and the public. Except when an extension of this period has been granted by the lead agency, the Council will not accept a referral after that date.

(c) The referral shall consist of:

(1) A copy of the letter signed by the head of the referring agency and delivered to the lead agency informing the lead agency of the referral and the reasons for it, and requesting that no action be taken to implement the matter until the Council acts upon the referral. The letter shall include a copy of the statement referred to in (c)(2) below.

(2) A statement supported by factual evidence leading to the conclusion that the matter is unsatisfactory from the standpoint of public health or welfare or environmental quality. The statement shall:

(i) Identify any material facts in controversy and incorporate (by reference if appropriate) agreed upon facts,

(ii) Identify any existing environmental requirements or policies which would be violated by the matter,

(iii) Present the reasons why the referring agency believes the matter is environmentally unsatisfactory,

(iv) Contain a finding by the agency whether the issue raised is of national importance because of the threat to national environmental resources or policies or for some other reason,

(v) Review the steps taken by the referring agency to bring its concerns to the attention of the lead agency at the earliest possible time, and

(vi) Give the referring agency's recommendations as to what mitigation alternative, further study, or other course of action (including abandonment of the matter) are necessary to remedy the situation.

(d) Not later than twenty-five (25) days after the referral to the Council the lead agency may deliver a response to the Council and the referring agency. If the lead agency requests more time and gives assurance that the matter will not go forward in the interim, the Council may grant an extension. The response shall:

(1) Address fully the issues raised in the referral.

(2) Be supported by evidence.

(3) Give the lead agency's response to the referring agency's recommendations.

(e) Interested persons (including the applicant) may deliver their views in writing to the Council. Views in support of the referral should be delivered not later than the referral. Views in support of the response shall be delivered not later than the response.

(f) Not later than twenty-five (25) days after receipt of both the referral and any response or upon being informed that there will be no response (unless the lead agency agrees to a longer time), the Council may take one or more of the following actions:

(1) Conclude that the process of referral and response has successfully resolved the problem.

(2) Initiate discussions with the agencies with the objective of mediation with referring and lead agencies.

(3) Hold public meetings or hearings to obtain additional views and information.

(4) Determine that the issue is not one of national importance and request the referring and lead agencies to pursue their decision process.

(5) Determine that the issue should be further negotiated by the referring and lead agencies and is not appropriate for Council consideration until one or more heads of agencies report to the Council that the agencies' disagreements are irreconcilable.

(6) Publish its findings and recommendations (including where appropriate a finding that the submitted evidence does not support the position of an agency).

(7) When appropriate, submit the referral and the response together with the Council's recommendation to the President for action.

(g) The Council shall take no longer than 60 days to complete the actions specified in paragraph (f) (2), (3), or (5) of this section.

(h) When the referral involves an action required by statute to be determined on the record after opportunity for agency hearing, the referral shall be conducted in a manner consistent with 5 U.S.C. 557(d) (Administrative Procedure Act).

PART 1505—NEPA AND AGENCY DECISIONMAKING

1505.1 Agency decisionmaking procedures
1505.2 Record of decision in cases requiring environmental impact statements
1505.3 Implementing the decision

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), Section 309 of the Clean Air Act, as

amended (42 U.S.C. 7609), and Executive Order 11514, Protection and Enhancement of Environmental Quality (March 5, 1970, as amended by Executive Order 11991, May 24, 1977).

§ 1505.1 AGENCY DECISIONMAKING PROCEDURES

Agencies shall adopt procedures (§ 1507.3) to ensure that decisions are made in accordance with the policies and purposes of the Act. Such procedures shall include but not be limited to:

(a) Implementing procedures under section 102(2) to achieve the requirements of sections 101 and 102(1).

(b) Designating the major decision points for the agency's principal programs likely to have a significant effect on the human environment and assuring that the NEPA process corresponds with them.

(c) Requiring that relevant environmental documents, comments, and responses be part of the record in formal rulemaking or adjudicatory proceedings.

(d) Requiring that relevant environmental documents, comments, and responses accompany the proposal through existing agency review processes so that agency officials use the statement in making decisions.

(e) Requiring that the alternatives considered by the decisionmaker are encompassed by the range of alternatives discussed in the relevant environmental documents and that the decisionmaker consider the alternatives described in the environmental impact statement. If another decision document accompanies the relevant environmental documents to the decisionmaker, agencies are encouraged to make available to the public before the decision is made any part of that document that relates to the comparison of alternatives.

§ 1505.2 RECORD OF DECISION IN CASES REQUIRING ENVIRONMENTAL IMPACT STATEMENTS

At the time of its decision (§ 1506.10) or, if appropriate, its recommendation to Congress, each agency shall prepare a concise public record of decision. The record, which may be integrated into any other record prepared by the agency, including that required by OMB Circular A–95 (Revised), part I, sections 6 (c) and (d), and part II, section 5(b) (4), shall:

(a) State what the decision was.

(b) Identify all alternatives considered by the agency in reaching its decision, specifying the alternative or alternatives which were considered to be environmentally preferable. An agency may discuss preferences among alternatives based on relevant factors including economic and technical considerations and agency statutory missions. An agency shall identify and discuss all such factors including any essential considerations of national policy which were balanced by the agency in making its decision and state how those considerations entered into its decision.

(c) State whether all practicable means to avoid or minimize environmental harm from the alternative selected have been adopted, and if not, why they were not. A monitoring and enforcement program shall be adopted and summarized where applicable for any mitigation.

§ 1505.3 IMPLEMENTING THE DECISION

Agencies may provide for monitoring to assure that their decisions are carried out and should do so in important cases. Mitigation (§ 1505.2(c)) and other conditions established in the environmental impact statement or during its review and committed as part of the decision shall be implemented by the lead agency or other appropriate consenting agency. The lead agency shall:

(a) Include appropriate conditions in grants, permits or other approvals.

(b) Condition funding of actions on mitigation.

(c) Upon request, inform cooperating or commenting agencies on progress in carrying out mitigation measures which they have proposed and which were adopted by the agency making the decision.

(d) Upon request, make available to the public the results of relevant monitoring.

PART 1506—OTHER REQUIREMENTS OF NEPA

1506.1 Limitations on actions during NEPA process
1506.2 Elimination of duplication with State and local procedures
1506.3 Adoption
1506.4 Combining documents
1506.5 Agency responsibility
1506.6 Public involvement
1506.7 Further guidance
1506.8 Proposals for legislation
1506.9 Filing requirements
1506.10 Timing of agency action
1506.11 Emergencies
1506.12 Effective date

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and Executive Order 11514, Protection and Enhancement of Environmental Quality (March 5, 1970, as amended by Executive Order 11991, May 24, 1977).

§ 1506.1 LIMITATIONS ON ACTIONS DURING NEPA PROCESS

(a) Until an agency issues a record of decision as provided in § 1505.2 (except as provided in paragraph (c) of this section), no action concerning the proposal shall be taken which would:

(1) Have an adverse environmental impact; or

(2) Limit the choice of reasonable alternatives.

(b) If any agency is considering an application from a non-Federal entity, and is aware that the applicant is about to take an action within the agency's jurisdiction that would meet either of the criteria in paragraph (a) of this section, then the agency shall promptly notify the applicant that the agency will take appropriate action to insure that the objectives and procedures of NEPA are achieved.

(c) While work on a required program environmental impact statement is in progress and the action is not covered by an existing program statement, agencies shall not undertake in the interim any major Federal action covered by the program which may significantly affect the quality of the human environment unless such action:

(1) Is justified independently of the program;

(2) Is itself accompanied by an adequate environmental impact statement; and

(3) Will not prejudice the ultimate decision on the program. Interim action prejudices the ultimate decision on the program when it tends to determine subsequent development or limit alternatives.

(d) This section does not preclude development by applicants of plans or designs or performance of other work necessary to support an application for Federal, State or local permits or assistance. Nothing in this section shall preclude Rural Electrification Administration approval of minimal expenditures not affecting the environment (*e.g.* long leadtime equipment and purchase options) made by non-governmental entities seeking loan guarantees from the Administration.

§ 1506.2 ELIMINATION OF DUPLICATION WITH STATE AND LOCAL PROCEDURES

(a) Agencies authorized by law to cooperate with State agencies of statewide jurisdiction pursuant to section 102(2)(D) of the Act may do so.

(b) Agencies shall cooperate with State and local agencies to the fullest extent possible to reduce duplication between NEPA and State and local requirements, unless the agencies are specifically barred from doing so by some other law. Except for cases covered by paragraph (a) of this section, such cooperation shall to the fullest extent possible include:

(1) Joint planning processes.
(2) Joint environmental research and studies.
(3) Joint public hearings (except where otherwise provided by statute).
(4) Joint environmental assessments.

(c) Agencies shall cooperate with State and local agencies to the fullest extent possible to reduce duplication between NEPA and comparable State and local requirements, unless the agencies are specifically barred from doing so by some other law. Except for cases covered by paragraph (a) of this section, such cooperation shall to the fullest extent possible include joint environmental impact statements. In such cases one or more Federal agencies and one or more State or local agencies shall be joint lead agencies. Where State laws or local ordinances have environmental impact statement requirements in addition to but not in conflict with those in NEPA, Federal agencies shall cooperate in fulfilling these requirements as well as those of Federal laws so that one document will comply with all applicable laws.

(d) To better integrate environmental impact statements into State or local planning processes, statements shall discuss any inconsistency of a proposed action with any approved State or local plan and laws (whether or not federally sanctioned). Where an inconsistency exists, the statement should describe the extent to which the agency would reconcile its proposed action with the plan or law.

§ 1506.3 ADOPTION

(a) An agency may adopt a Federal draft or final environmental impact statement or portion thereof provided that the statement or portion thereof meets the standards for an adequate statement under these regulations.

(b) If the actions covered by the original environmental impact statement and the proposed action are substantially the same, the agency adopting another agency's statement is not required to recirculate it except as a final statement. Otherwise the adopting agency shall treat the statement as a draft and recirculate it (except as provided in paragraph (c) of this section).

(c) A cooperating agency may adopt without recirculating the environmental impact statement of a lead agency when, after an independent review of the statement, the cooperating agency concludes that its comments and suggestions have been satisfied.

(d) When an agency adopts a statement which is not final within the agency that prepared it, or when the action it assesses is the subject of a referral under part 1504, or when the statement's adequacy is the subject of a judicial action which is not final, the agency shall so specify.

§ 1506.4 COMBINING DOCUMENTS

Any environmental document in compliance with NEPA may be combined with any other agency document to reduce duplication and paperwork.

§ 1506.5 AGENCY RESPONSIBILITY

(a) *Information.* If an agency requires an applicant to submit environmental information for possible use by the agency in preparing an environmental

impact statement, then the agency should assist the applicant by outlining the types of information required. The agency shall independently evaluate the information submitted and shall be responsible for its accuracy. If the agency chooses to use the information submitted by the applicant in the environmental impact statement, either directly or by reference, then the names of the persons responsible for the independent evaluation shall be included in the list of preparers (§ 1502.17). It is the intent of this subparagraph that acceptable work not be redone, but that it be verified by the agency.

(b) *Environmental assessments.* If an agency permits an applicant to prepare an environmental assessment, the agency, besides fulfilling the requirements of paragraph (a) of this section, shall make its own evaluation of the environmental issues and take responsibility for the scope and content of the environmental assessment.

(c) *Environmental impact statements.* Except as provided in §§ 1506.2 and 1506.3 any environmental impact statement prepared pursuant to the requirements of NEPA shall be prepared directly by or by a contractor selected by the lead agency or where appropriate under § 1501.6(b), a cooperating agency. It is the intent of these regulations that the contractor be chosen solely by the lead agency, or by the lead agency in cooperation with cooperating agencies, or where appropriate by a cooperating agency to avoid any conflict of interest. Contractors shall execute a disclosure statement prepared by the lead agency, or where appropriate the cooperating agency, specifying that they have no financial or other interest in the outcome of the project. If the document is prepared by contract, the responsible Federal official shall furnish guidance and participate in the preparation and shall independently evaluate the statement prior to its approval and take responsibility for its scope and contents. Nothing in this section is intended to prohibit any agency from requesting any person to submit information to it or to prohibit any person from submitting information to any agency.

§ 1506.6 PUBLIC INVOLVEMENT

Agencies shall: (a) Make diligent efforts to involve the public in preparing and implementing their NEPA procedures.

(b) Provide public notice of NEPA-related hearings, public meetings, and the availability of environmental documents so as to inform those persons and agencies who may be interested or affected.

(1) In all cases the agency shall mail notice to those who have requested it on an individual action.

(2) In the case of an action with effects of national concern notice shall include publication in the FEDERAL REGISTER and notice by mail to national organizations reasonably expected to be interested in the matter and may include listing in the *102 Monitor*. An agency engaged in rulemaking may provide notice by mail to national organizations who have requested that notice regularly be provided. Agencies shall maintain a list of such organizations.

(3) In the case of an action with effects primarily of local concern the notice may include:

(i) Notice to State and areawide clearinghouses pursuant to OMB Circular A–95 (Revised).

(ii) Notice to Indian tribes when effects may occur on reservations.

(iii) Following the affected State's public notice procedures for comparable actions.

(iv) Publication in local newspapers (in papers of general circulation rather than legal papers).

(v) Notice through other local media.

(vi) Notice to potentially interested community organizations including small business associations.

(vii) Publication in newsletters that may be expected to reach potentially interested persons.

(viii) Direct mailing to owners and occupants of nearby or affected property.

(ix) Posting of notice on and off site in the area where the action is to be located.

(c) Hold or sponsor public hearings or public meetings whenever appropriate or in accordance with statutory requirements applicable to the agency. Criteria shall include whether there is:

(1) Substantial environmental controversy concerning the proposed action or substantial interest in holding the hearing.

(2) A request for a hearing by another agency with jurisdiction over the action supported by reasons why a hearing will be helpful. If a draft environmental impact statement is to be considered at a public hearing, the agency should make the statement available to the public at least 15 days in advance (unless the purpose of the hearing is to provide information for the draft environmental impact statement).

(d) Solicit appropriate information from the public.

(e) Explain in its procedures where interested persons can get information or status reports on environmental impact statements and other elements of the NEPA process.

(f) Make environmental impact statements, the comments received, and any underlying documents available to the public pursuant to the provisions of the Freedom of Information Act (5 U.S.C. 552), without regard to the exclusion for interagency memoranda where such memoranda transmit comments of Federal agencies on the environmental impact of the proposed action. Materials to be made available to the public shall be provided to the public without charge to the extent practicable, or at a fee which is not more than the actual costs of reproducing copies required to be sent to other Federal agencies, including the Council.

§ 1506.7 FURTHER GUIDANCE

The Council may provide further guidance concerning NEPA and its procedures including:

(a) A handbook which the Council may supplement from time to time, which shall in plain language provide guidance and instructions concerning the application of NEPA and these regulations.

(b) Publication of the Council's Memoranda to Heads of Agencies.

(c) In conjunction with the Environmental Protection Agency and the publication of the 102 Monitor, notice of:

(1) Research activities;

(2) Meetings and conferences related to NEPA; and

(3) Successful and innovative procedures used by agencies to implement NEPA.

§ 1506.8 PROPOSALS FOR LEGISLATION

(a) The NEPA process for proposals for legislation (§ 1508.17) significantly affecting the quality of the human environment shall be integrated with the legislative process of the Congress. A legislative environmental impact statement is the detailed statement required by law to be included in a recommendation or report on a legislative proposal to Congress. A legislative environmental impact statement shall be considered part of the formal transmittal of a legislative proposal to Congress; however, it may be transmitted to Congress up to 30 days later in order to allow time for completion of an accurate statement which can serve as the basis for public and Congressional debate. The statement must be available in time for Congressional hearings and deliberations.

(b) Preparation of a legislative environmental impact statement shall conform to the requirements of these regulations except as follows:

(1) There need not be a scoping process.

(2) The legislative statement shall be prepared in the same manner as a draft statement, but shall be considered the "detailed statement" required by statute; *Provided,* That when any of the following conditions exist both the draft and final environmental impact statement on the legislative proposal shall be prepared and circulated as provided by §§ 1503.1 and 1506.10.

(i) A Congressional Committee with jurisdiction over the proposal has a rule requiring both draft and final environmental impact statements.

(ii) The proposal results from a study process required by statute (such as those required by the Wild and Scenic Rivers Act (16 U.S.C. 1271 et seq.) and the Wilderness Act (16 U.S.C. 1131 et seq.)).

(iii) Legislative approval is sought for Federal or federally assisted construction or other projects which the agency recommends be located at specific geographic locations. For proposals requiring an environmental impact statement for the acquisition of space by the General Services Administration, a draft statement shall accompany the Prospectus or the 11(b) Report of Building Project Surveys to the Congress, and a final statement shall be completed before site acquisition.

(iv) The agency decides to prepare draft and final statements.

(c) Comments on the legislative statement shall be given to the lead agency which shall forward them along with its own responses to the Congressional committees with jurisdiction.

§ 1506.9 FILING REQUIREMENTS

Environmental impact statements together with comments and responses shall be filed with the Environmental Protection Agency, attention Office of Federal Activities (A–104), 401 M Street SW, Washington, D.C. 20460. Statements shall be filed with EPA no earlier than they are also transmitted to commenting agencies and made available to the public. EPA shall deliver one copy of each statement to the Council, which shall satisfy the requirement of availability to the President. EPA may issue guidelines to agencies to implement its responsibilities under this section and § 1506.10 below.

§ 1506.10 TIMING OF AGENCY ACTION

(a) The Environmental Protection Agency shall publish a notice in the FEDERAL REGISTER each week of the environmental impact statements filed during the preceding week. The minimum time periods set forth in this section shall be calculated from the date of publication of this notice.

(b) No decision on the proposed action shall be made or recorded under § 1505.2 by a Federal agency until the later of the following dates:

(1) Ninety (90) days after publication of the notice described above in paragraph (a) of this section for a draft environmental impact statement.

(2) Thirty (30) days after publication of the notice described above in paragraph (a) of this section for a final environmental impact statement.

An exception to the rules on timing may be made in the case of an agency decision which is subject to a formal internal appeal. Some agencies have a formally established appeal process which allows other agencies or the public to take appeals on a decision and make their views known, after publication of the final environmental impact statement. In such cases, where a real opportunity exists to alter the decision, the decision may be made and recorded at the same time the environmental impact statement is published. This means that the period for appeal of the decision and the 30-day period prescribed in paragraph (b)(2) of this section may run concurrently. In such cases the environmental impact statement shall explain the timing and the public's right of appeal.

An agency engaged in rulemaking under the Administrative Procedure Act or other statute for the purpose of protecting the public health or safety, may waive the time period in paragraph (b)(2) of this section and publish a decision on the final rule simultaneously with publication of the notice of the availability of the final environmental impact statement as described in paragraph (a) of this section.

(c) If the final environmental impact statement is filed within ninety (90) days after a draft environmental impact statement is filed with the Environmental Protection Agency, the minimum thirty (30) day period and the minimum ninety (90) day period may run concurrently. However, subject to paragraph (d) of this section agencies shall allow not less than 45 days for comments on draft statements.

(d) The lead agency may extend prescribed periods. The Environmental Protection Agency may upon a showing by the lead agency of compelling reasons of national policy reduce the prescribed periods and may upon a showing by any other Federal agency of compelling reasons of national policy also extend prescribed periods, but only after consultation with the lead agency. (Also see § 1507.3(d).) Failure to file timely comments shall not be a sufficient reason for extending a period. If the lead agency does not concur with the extension of time, EPA may not extend it for more than 30 days. When the Environmental Protection Agency reduces or extends any period of time it shall notify the Council.

§ 1506.11 EMERGENCIES

Where emergency circumstances make it necessary to take an action with significant environmental impact without observing the provisions of these regulations, the Federal agency taking the action should consult with the Council about alternative arrangements. Agencies and the Council will limit such arrangements to actions necessary to control the immediate impacts of the emergency. Other actions remain subject to NEPA review.

§ 1506.12 EFFECTIVE DATE

The effective date of these regulations is July 30, 1979, except that for agencies that administer programs that qualify under sec. 102(2)(D) of the Act or under sec. 104(h) of the Housing and Community Development Act of 1974 an additional four months shall be allowed for the State or local agencies to adopt their implementing procedures.

(a) These regulations shall apply to the fullest extent practicable to ongoing activities and environmental documents begun before the effective date. These regulations do not apply to an environmental impact statement or supplement if the draft statement was filed before the effective date of these regulations. No completed environmental documents need be redone by reason of these regulations. Until these regulations are applicable, the Council's guidelines published in the FEDERAL REGISTER of August 1, 1973, shall continue to be applicable. In cases where these regulations are applicable the guidelines are superseded. However, nothing shall prevent an agency from proceeding under these regulations at an earlier time.

(b) NEPA shall continue to be applicable to actions begun before January 1, 1970, to the fullest extent possible

PART 1507—AGENCY COMPLIANCE

1507.1 Compliance
1507.2 Agency Capability to Comply
1507.3 Agency Procedures

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and Executive Order 11514, Protection and

Enhancement of Environmental Quality (March 5, 1970, as amended by Executive Order 11991, May 24, 1977).

§ 1507.1 COMPLIANCE

All agencies of the Federal Government shall comply with these regulations. It is the intent of these regulations to allow each agency flexibility in adapting its implementing procedures authorized by § 1507.3 to the requirements of other applicable laws.

§ 1507.2 AGENCY CAPABILITY TO COMPLY

Each agency shall be capable (in terms of personnel and other resources) of complying with the requirements enumerated below. Such compliance may include use of other's resources, but the using agency shall itself have sufficient capability to evaluate what others do for it. Agencies shall:

(a) Fulfill the requirements of Sec. 102(2)(A) of the Act to utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on the human environment. Agencies shall designate a person to be responsible for overall review of agency NEPA compliance.

(b) Identify methods and procedures required by Sec. 102(2)(B) to insure that presently unquantified environmental amenities and values may be given appropriate consideration.

(c) Prepare adequate environmental impact statements pursuant to Sec. 102(2)(C) and comment on statements in the areas where the agency has jurisdiction by law or special expertise or is authorized to develop and enforce environmental standards.

(d) Study, develop, and describe alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources. This requirement of Sec. 102(2)(E) extends to all such proposals, not just the more limited scope of Sec. 102(2)(C)(iii) where the discussion of alternatives is confined to impact statements.

(e) Comply with the requirements of Sec. 102(2)(H) that the agency initiate and utilize ecological information in the planning and development of resource-oriented projects.

(f) Fulfill the requirements of sections 102(2)(F), 102(2)(G), and 102(2)(I), of the Act and of Executive Order 11514, Protection and Enhancement of Environmental Quality, Sec. 2.

§ 1507.3 AGENCY PROCEDURES

(a) Not later than eight months after publication of these regulations as finally adopted in the FEDERAL REGISTER, or five months after the establishment of an agency, whichever shall come later, each agency shall as necessary adopt procedures to supplement these regulations. When the agency is a department, major subunits are encouraged (with the consent of the department) to adopt their own procedures. Such procedures shall not paraphrase these regulations. They shall confine themselves to implementing procedures. Each agency shall consult with the Council while developing its procedures and before publishing them in the FEDERAL REGISTER for comment. Agencies with similar programs should consult with each other and the Council to coordinate their procedures, especially for programs requesting similar information from applicants. The procedures shall be adopted only after an opportunity for public review and after review by the Council for conformity with the Act and these regulations. The Council shall complete its review within 30 days. Once in effect they shall be filed with the Council and made readily available to the public. Agencies are encouraged to publish explanatory guidance for these regulations and their own procedures. Agencies shall continue to review their policies and procedures and in consultation with the Council

to revise them as necessary to ensure full compliance with the purposes and provisions of the Act.

(b) Agency procedures shall comply with these regulations except where compliance would be inconsistent with statutory requirements and shall include:

(1) Those procedures required by §§ 1501.2(d), 1502.9(c)(3), 1505.1, 1506.6(e), and 1508.4.

(2) Specific criteria for and identification of those typical classes of action:

(i) Which normally do require environmental impact statements.

(ii) Which normally do not require either an environmental impact statement or an environmental assessment (categorical exclusions (§ 1508.4)).

(iii) Which normally require environmental assessments but not necessarily environmental impact statements.

(c) Agency procedures may include specific criteria for providing limited exceptions to the provisions of these regulations for classified proposals. They are proposed actions which are specifically authorized under criteria established by an Executive Order or statute to be kept secret in the interest of national defense or foreign policy and are in fact properly classified pursuant to such Executive Order or statute. Environmental assessments and environmental impact statements which address classified proposals may be safeguarded and restricted from public dissemination in accordance with agencies' own regulations applicable to classified information. These documents may be organized so that classified portions can be included as annexes, in order that the unclassified portions can be made available to the public.

(d) Agency procedures may provide for periods of time other than those presented in § 1506.10 when necessary to comply with other specific statutory requirements.

(e) Agency procedures may provide that where there is a lengthy period between the agency's decision to prepare an environmental impact statement and the time of actual preparation, the notice of intent required by § 1501.7 may be published at a reasonable time in advance of preparation of the draft statement.

PART 1508—TERMINOLOGY AND INDEX

1508.1 Terminology
1508.2 Act
1508.3 Affecting
1508.4 Categorical Exclusion
1508.5 Cooperating Agency
1508.6 Council
1508.7 Cumulative Impact
1508.8 Effects
1508.9 Environmental Assessment
1508.10 Environmental Document
1508.11 Environmental Impact Statement
1508.12 Federal Agency
1508.13 Finding of No Significant Impact
1508.14 Human Environment
1508.15 Jurisdiction By Law
1508.16 Lead Agency
1508.17 Legislation
1508.18 Major Federal Action
1508.19 Matter
1508.20 Mitigation
1508.21 NEPA Process

1508.22 Notice of Intent
1508.23 Proposal
1508.24 Referring Agency
1508.25 Scope
1508.26 Special Expertise
1508.27 Significantly
1508.28 Tiering

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 *et seq.*), Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and Executive Order 11514, Protection and Enhancement of Environmental Quality (March 5, 1970, as amended by Executive Order 11991, May 24, 1977).

§ 1508.1 TERMINOLOGY

The terminology of this part shall be uniform throughout the Federal Government.

§ 1508.2 ACT

"Act" means the National Environmental Policy Act, as amended (42 U.S.C. 4321, et seq.) which is also referred to as "NEPA."

§ 1508.3 AFFECTING

"Affecting" means will or may have an effect on.

§ 1508.4 CATEGORICAL EXCLUSION

"Categorical Exclusion" means a category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a Federal agency in implementation of these regulations (§ 1507.3) and for which, therefore, neither an environmental assessment nor an environmental impact statement is required. An agency may decide in its procedures or otherwise, to prepare environmental assessments for the reasons stated in § 1508.9 even though it is not required to do so. Any procedures under this section shall provide for extraordinary circumstances in which a normally excluded action may have a significant environmental effect.

§ 1508.5 COOPERATING AGENCY

"Cooperating Agency" means any Federal agency other than a lead agency which has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major Federal action significantly affecting the quality of the human environment. The selection and responsibilities of a cooperating agency are described in § 1501.6. A State or local agency of similar qualifications or, when the effects are on a reservation, an Indian tribe, may by agreement with the lead agency become a cooperating agency.

§ 1508.6 COUNCIL

"Council" means the Council on Environmental Quality established by Title II of the Act.

§ 1508.7 CUMULATIVE IMPACT

"Cumulative impact" is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts

can result from individually minor but collectively significant actions taking place over a period of time.

§ 1508.8 EFFECTS

"Effects" include:

(a) Direct effects, which are caused by the action and occur at the same time and place.

(b) Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

Effects and impacts as used in these regulations are synonymous. Effects includes ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions which may have both beneficial and detrimental effects, even if on balance the agency believes that the effect will be beneficial.

§ 1508.9 ENVIRONMENTAL ASSESSMENT

"Environmental Assessment":

(a) Means a concise public document for which a Federal agency is responsible that serves to:

(1) Briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact.

(2) Aid an agency's compliance with the Act when no environmental impact statement is necessary.

(3) Facilitate preparation of a statement when one is necessary.

(b) Shall include brief discussions of the need for the proposal, of alternatives as required by sec. 102(2)(E), of the environmental impacts of the proposed action and alternatives, and a listing of agencies and persons consulted.

§ 1508.10 ENVIRONMENTAL DOCUMENT

"Environmental document" includes the documents specified in § 1508.9 (environmental assessment), § 1508.11 (environmental impact statement), § 1508.13 (finding of no significant impact), and § 1508.22 (notice of intent).

§ 1508.11 ENVIRONMENTAL IMPACT STATEMENT

"Environmental Impact Statement" means a detailed written statement as required by Sec. 102(2)(C) of the Act.

§ 1508.12 FEDERAL AGENCY

"Federal agency" means all agencies of the Federal Government. It does not mean the Congress, the Judiciary, or the President, including the performance of staff functions for the President in his Executive Office. It also includes for purposes of these regulations States and units of general local government and Indian tribes assuming NEPA responsibilities under section 104(h) of the Housing and Community Development Act of 1974.

§ 1508.13 FINDING OF NO SIGNIFICANT IMPACT

"Finding of No Significant Impact" means a document by a Federal agency briefly presenting the reasons why an action, not otherwise excluded (§ 1508.4), will not have a significant effect on the human environment and

for which an environmental impact statement therefore will not be prepared. It shall include the environmental assessment or a summary of it and shall note any other environmental documents related to it (§ 1501.7(a)(5)). If the assessment is included, the finding need not repeat any of the discussion in the assessment but may incorporate it by reference.

§ 1508.14 HUMAN ENVIRONMENT

"Human Environment" shall be interpreted comprehensively to include the natural and physical environmental and the relationship of people with that environment. (See the definition of "effects" (§ 1508.8).) This means that economic or social effects are not intended by themselves to require preparation of an environmental impact statement. When an environmental impact statement is prepared and economic or social and natural or physical environmental effects are interrelated, then the environmental impact statement will discuss all of these effects on the human environment.

§ 1508.15. JURISDICTION BY LAW

"Jurisdiction by law" means agency authority to approve, veto, or finance all or part of the proposal.

§ 1508.16 LEAD AGENCY

"Lead Agency" means the agency or agencies preparing or having taken primary responsibility for preparing the environmental impact statement.

§ 1508.17 LEGISLATION

"Legislation" includes a bill or legislative proposal to Congress developed by or with the significant cooperation and support of a Federal agency, but does not include requests for appropriations. The test for significant cooperation is whether the proposal is in fact predominantly that of the agency rather than another source. Drafting does not by itself constitute significant cooperation. Proposals for legislation include requests for ratification of treaties. Only the agency which has primary responsibility for the subject matter involved will prepare a legislative environmental impact statement.

§ 1508.18 MAJOR FEDERAL ACTION

"Major Federal action" includes actions with effects that may be major and which are potentially subject to Federal control and responsibility. Major reinforces but does not have a meaning independent of significantly (§ 1508.27). Actions include the circumstance where the responsible officials fail to act and that failure to act is reviewable by courts or administrative tribunals under the Administrative Procedure Act or other applicable law as agency action.

(a) Actions include new and continuing activities, including projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by federal agencies; new or revised agency rules, regulations, plans, policies, or procedures; and legislative proposals (§§ 1506.8, 1508.17). Actions do not include funding assistance solely in the form of general revenue sharing funds, distributed under the State and Local Fiscal Assistance Act of 1972, 31 U.S.C. 1221 et seq., with no Federal agency control over the subsequent use of such funds. Actions do not include bringing judicial or administrative civil or criminal enforcement actions.

(b) Federal actions tend to fall within one of the following categories:

(1) Adoption of official policy, such as rules, regulations, and interpretations adopted pursuant to the Administrative Procedure Act, 5 U.S.C. 551 et seq.; treaties and international conventions or agreements; formal documents establishing an agency's policies which will result in or substantially alter agency programs.

(2) Adoption of formal plans, such as official documents prepared or approved by federal agencies which guide or prescribe alternative uses of federal resources, upon which future agency actions will be based.

(3) Adoption of programs, such as a group of concerted actions to implement a specific policy or plan; systematic and connected agency decisions allocating agency resources to implement a specific statutory program or executive directive.

(4) Approval of specific projects, such as construction or management activities located in a defined geographic area. Projects include actions approved by permit or other regulatory decision as well as federal and federally assisted activities.

§ 1508.19 MATTER

"Matter" includes for purposes of Part 1504:

(a) With respect to the Environmental Protection Agency, any proposed legislation, project, action, or regulation as those terms are used in Section 309(a) of the Clean Air Act (42 U.S.C. 7609).

(b) With respect to all other agencies, any proposed major Federal action to which section 102(2)(C) of NEPA applies.

§ 1508.20 MITIGATION

"Mitigation" includes:

(a) Avoiding the impact altogether by not taking a certain action or parts of an action.

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

(e) Compensating for the impact by replacing or providing substitute resources or environments.

§ 1508.21 NEPA PROCESS

"NEPA process" means all measures necessary for compliance with the requirements of Section 2 and Title I of NEPA.

§ 1508.22 NOTICE OF INTENT

"Notice of Intent" means a notice that an environmental impact statement will be prepared and considered. The notice shall briefly:

(a) Describe the proposed action and possible alternatives.

(b) Describe the agency's proposed scoping process including whether, when, and where any scoping meeting will be held.

(c) State the name and address of a person within the agency who can answer questions about the proposed action and the environmental impact statement.

§ 1508.23 PROPOSAL

"Proposal" exists at that stage in the development of an action when an agency subject to the Act has a goal and is actively preparing to make a decision on one or more alternative means of accomplishing that goal and the effects can be meaningfully evaluated. Preparation of an environmental impact statement on a proposal should be timed (§ 1502.5) so that the final statement may be completed in time for the statement to be included in any recommendation or report on the proposal. A proposal may exist in fact as well as by agency declaration that one exists.

§ 1508.24 REFERRING AGENCY

"Referring agency" means the federal agency which has referred any matter to the Council after a determination that the matter is unsatisfactory from the standpoint of public health or welfare or environmental quality.

§ 1508.25 SCOPE

Scope consists of the range of actions, alternatives, and impacts to be considered in an environmental impact statement. The scope of an individual statement may depend on its relationships to other statements (§§1502.20 and 1508.28). To determine the scope of environmental impact statements, agencies shall consider 3 types of actions, 3 types of alternatives, and 3 types of impacts. They include:

(a) Actions (other than unconnected single actions) which may be:

(1) Connected actions, which means that they are closely related and therefore should be discussed in the same impact statement. Actions are connected if they:

(i) Automatically trigger other actions which may require environmental impact statements.

(ii) Cannot or will not proceed unless other actions are taken previously or simultaneously.

(iii) Are interdependent parts of a larger action and depend on the larger action for their justification.

(2) Cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact statement.

(3) Similar actions, which when viewed with other reasonably foreseeable or proposed agency actions, have similarities that provide a basis for evaluating their environmental consequences together, such as common timing or geography. An agency may wish to analyze these actions in the same impact statement. It should do so when the best way to assess adequately the combined impacts of similar actions or reasonable alternatives to such actions is to treat them in a single impact statement.

(b) Alternatives, which include: (1) No action alternative. (2) Other reasonable courses of actions. (3) Mitigation measures (not in the proposed action).

(c) Impacts, which may be: (1) Direct. (2) Indirect. (3) Cumulative.

§ 1508.26 SPECIAL EXPERTISE

"Special expertise" means statutory responsibility, agency mission, or related program experience.

§ 1508.27 SIGNIFICANTLY

"Significantly" as used in NEPA requires considerations of both context and intensity:

(a) *Context.* This means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of the proposed action. For instance, in the case of a site-specific action, significance would usually depend upon the effects in the locale rather than in the world as a whole. Both short- and long-term effects are relevant.

(b) *Intensity.* This refers to the severity of impact. Responsible officials must bear in mind that more than one agency may make decisions about partial aspects of a major action. The following should be considered in evaluating intensity:

(1) Impacts that may be both beneficial and adverse. A significant effect may exist even if the Federal agency believes that on balance the effect will be beneficial.

(2) The degree to which the proposed action affects public health or safety.

(3) Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.

(4) The degree to which the effects on the quality of the human environment are likely to be highly controversial.

(5) The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.

(6) The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.

(7) Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

(8) The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.

(9) The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

(10) Whether the action threatens a violation of Federal, State, or local law or requirements imposed for the protection of the environment.

§ 1508.28 TIERING

"Tiering" refers to the coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basinwide program statements or ultimately site-specific statements) incorporating by reference the general discussions and concentrating solely on the issues specific to the statement subsequently prepared. Tiering is appropriate when the sequence of statements or analyses is:

(a) From a program, plan, or policy environmental impact statement to a program, plan, or policy statement or analysis of lesser scope or to a site-specific statement or analysis.

(b) From an environmental impact statement on a specific action at an early stage (such as need and site selection) to a supplement (which is preferred) or a subsequent statement or analysis at a later stage (such as environmental mitigation). Tiering in such cases is appropriate when it helps the lead agency to focus on the issues which are ripe for decision and exclude from consideration issues already decided or not yet ripe.

Act	1508.2
Action	1508.18, 1508.25
Action-forcing	1500.1, 1502.1
Adoption	1500.4(n), 1500.5(h), 1506.3
Affected Environment	1502.10(f), 1502.15
Affecting	1502.3, 1508.3
Agency Authority	1500.6
Agency Capability	1501.2(a), 1507.2
Agency Compliance	1507.1
Agency Procedures	1505.1, 1507.3
Agency Responsibility	1506.5
Alternatives	1501.2(c), 1502.2, 1502.10(e), 1502.14, 1505.1(e), 1505.2, 1507.2(d), 1508.25(b)
Appendices	1502.10(k), 1502.18, 1502.24
Applicant	1501.2(d)(1), 1501.4(b), 1501.8(a), 1502.19(b), 1503.1(a)(3), 1504.3(e), 1506.1(d), 1506.5(a), 1506.5(b)
Apply NEPA Early in the Process	1501.2
Categorical Exclusion	1500.4(p), 1500.5(k), 1501.4(a), 1507.3(b), 1508.4
Circulating of Environmental Impact Statement.	1502.19, 1506.3
Classified Information	1507.3(c)
Clean Air Act	1504.1, 1508.19(a)
Combining Documents	1500.4(o), 1500.5(i), 1506.4
Commenting	1502.19, 1503.1, 1503.2, 1503.3, 1503.4, 1506.6(f)
Consultation Requirement	1500.4(k), 1500.5(g), 1501.7(a)(6), 1502.25
Context	1508.27(a)
Cooperating Agency	1500.5(b), 1501.1(b), 1501.5(c), 1501.5(f), 1501.6, 1503.1(a)(1), 1503.2, 1503.3, 1506.3(c), 1506.5(a), 1508.5
Cost-Benefit	1502.23
Council on Environmental Quality	1500.3, 1501.5(e), 1501.5(f), 1501.6(c), 1502.9(c)(4), 1504.1, 1504.2, 1504.3, 1506.6(f), 1506.9, 1506.10(e), 1506.11, 1507.3, 1508.6, 1508.24
Cover Sheet	1502.10(a), 1502.11
Cumulative Impact	1508.7, 1508.25(a), 1508.25(c)
Decisionmaking	1505.1, 1506.1
Decision points	1505.1(b)
Dependent	1508.25(a)
Draft Environmental Impact Statement.	1502.9(a)
Early Application of NEPA	1501.2
Economic Effects	1508.8
Effective Date	1506.12
Effects	1502.16, 1508.8
Emergencies	1506.11
Endangered Species Act	1502.25, 1508.27(b)(9)
Energy	1502.16(e)

Environmental Assessment	1501.3, 1501.4(b), 1501.4(c), 1501.7(b)(3), 1506.2(b)(4), 1506.5(b), 1508.4, 1508.9, 1508.10, 1508.13
Environmental Consequences	1502.10(g), 1502.16
Environmental Consultation Requirements.	1500.4(k), 1500.5(g), 1501.7(a)(6), 1502.25, 1503.3(c)
Environmental Documents	1508.10
Environmental Impact Statement	1500.4, 1501.4(c), 1501.7, 1501.3, 1502.1, 1502.2, 1502.3, 1502.4, 1502.5, 1502.6, 1502.7, 1502.8, 1502.9, 1502.10, 1502.11, 1502.12, 1502.13, 1502.14, 1502.15, 1502.16, 1502.17, 1502.18, 1502.19, 1502.20, 1502.21, 1502.22, 1502.23, 1502.24, 1502.25, 1506.2(b)(4), 1506.3, 1506.8, 1508.11
Environmental Protection Agency	1502.11(f), 1504.1, 1504.3, 1506.7(c), 1506.9, 1506.10, 1508.19(a)
Environmental Review Requirements.	1500.4(k), 1500.5(g), 1501.7(a)(6), 1502.25, 1503.3(c)
Expediter	1501.8(b)(2)
Federal Agency	1508.12
Filing	1506.9
Final Environmental Impact Statement.	1502.9(b), 1503.1, 1503.4(b)
Finding of No Significant Impact	1500.3, 1500.4(q), 1500.5(1), 1501.4(e), 1508.13
Fish and Wildlife Coordination Act	1502.25
Format for Environmental Impact Statement.	1502.10
Freedom of Information Act	1506.6(f)
Further Guidance	1506.7
Generic	1502.4(c)(2)
General Services Administration	1506.8(b)(5)
Geographic	1502.4(c)(1)
Graphics	1502.8
Handbook	1506.7(a)
Housing and Community Development Act.	1506.12, 1508.12
Human Environment	1502.3, 1502.22, 1508.14
Impacts	1508.8, 1508.25(c)
Implementing the Decision	1505.3
Incomplete or Unavailable Information.	1502.22
Incorporation by Reference	1500.4(j), 1502.21
Index	1502.10(j)
Indian Tribes	1501.2(d)(2), 1501.7(a)(1), 1502.15(c), 1503.1(a)(2)(ii), 1506.6(b)(3)(ii), 1508.5, 1508.12
Intensity	1508.27(b)
Interdisciplinary Preparation	1502.6, 1502.17
Interim Actions	1506.1
Joint Lead Agency	1501.5(b), 1506.2
Judicial Review	1500.3

Jurisdiction by Law	1508.15
Lead Agency	1500.5(c), 1501.1(c), 1501.5, 1501.6, 1501.7, 1501.8, 1504.3. 1506.2(b)(4), 1506.8(a), 1506.10(e), 1508.16
Legislation	1500.5(j), 1502.3, 1506.8, 1508.17, 1508.18(a)
Limitation on Action During NEPA Process.	1506.1
List of Preparers	1502.10(h), 1502.17
Local or State	1500.4(n), 1500.5(h), 1501.2(d)(2), 1501.5(b), 1501.5(d), 1501.7(a)(1), 1501.8(c), 1502.16(c), 1503.1(a)(2), 1506.2(b), 1506.6(b)(3), 1508.5, 1508.12, 1508.18
Major Federal Action	1502.3, 1508.18
Mandate	1500.3
Matter	1504.1, 1504.2, 1504.3, 1508.19
Methodology	1502.24
Mitigation	1502.14(h), 1502.16(h), 1503.3(d), 1505.2(c), 1505.3, 1508.20
Monitoring	1505.2(c), 1505.3
National Historic Preservation Act	1502.25
National Register of Historical Places	1508.27(b)(8)
Natural or Depletable Resource Requirements.	1502.16(f)
Need for Action	1502.10(d), 1502.13
NEPA Process	1508.21
Non-Federal Sponsor	1501.2(d)
Notice of Intent	1501.7, 1507.3(e), 1508.22
OMB Circular A-95	1503.1(a)(2)(iii), 1505.2, 1506.6(b)(3)(i)
102 Monitor	1506.6(b)(2), 1506.7(c)
Ongoing Activities	1506.12
Page Limits	1500.4(a), 1501.7(b), 1502.7
Planning	1500.5(a), 1501.2(b), 1502.4(a), 1508.18
Policy	1500.2, 1502.4(b), 1508.18(a)
Program Environmental Impact Statement.	1500.4(i), 1502.4, 1502.20, 1508.18
Programs	1502.4, 1508.18(b)
Projects	1508.18
Proposal	1502.4, 1502.5, 1506.8, 1508.23
Proposed Action	1502.10(e), 1502.14, 1506.2(c)
Public Health and Welfare	1504.1
Public Involvement	1501.4(e), 1503.1(a)(3), 1506.6
Purpose	1500.1, 1501.1, 1502.1, 1504.1
Purpose of Action	1502.10(d), 1502.13
Record of Decision	1505.2, 1506.1
Referrals	1504.1, 1504.2, 1504.3, 1506.3(d)
Referring Agency	1504.1, 1504.2, 1504.3
Response to Comments	1503.4
Rural Electrification Administration	1506.1(d)
Scientific Accuracy	1502.24
Scope	1502.4(a), 1502.9(a), 1508.25
Scoping	1500.4(b), 1501.1(d), 1501.4(d), 1501.7, 1502.9(a), 1506.8(a)

Significantly	1502.3, 1508.27
Similar	1508.25
Small Business Associations	1506.6(b)(3)(vi)
Social Effects	1508.8
Special Expertise	1508.26
Specificity of Comments	1500.4(1), 1503.3
State and Areawide Clearinghouses	1501.4(e)(2), 1503.1(a)(2)(iii), 1506.6(b)(3)(i)
State and Local	1500.4(n), 1500.5(h), 1501.2(d)(2), 1501.5(b), 1501.5(d), 1501.7(a)(1), 1501.8(c), 1502.16(c), 1503.1(a)(2), 1506.2(b), 1506.6(b)(3), 1508.5, 1508.12, 1508.18
State and Local Fiscal Assistance Act	1508.18(a)
Summary	1500.4(h), 1502.10(b), 1502.12
Supplements to Environmental Impact Statements.	1502.9(c)
Table of Contents	1502.10(c)
Technological Development	1502.4(c)(3)
Terminology	1508.1
Tiering	1500.4(i), 1502.4(d), 1502.20. 1508.28
Time Limits	1500.5(e), 1501.1(e), 1501.7(b)(2), 1501.8
Timing	1502.4, 1502.5, 1506.10
Treaties	1508.17
When to Prepare an Environmental Impact Statement.	1501.3
Wild and Scenic Rivers Act	1506.8(b)(ii)
Wilderness Act	1506.8(b)(ii)
Writing	1502.8

APPENDIX F

FEDERAL AGENCY NEPA CONTACTS

ACTION

Office of Policy and Planning, Room M–606, 806 Connecticut Avenue NW., Washington, D.C. 20525 (202) 254–6860

ADVISORY COUNCIL ON HISTORIC PRESERVATION

Office of Cultural Resource Preservation, Suite 536, 1522 K Street NW., Washington, D.C. 20005 (202) 254–3974

DEPARTMENT OF AGRICULTURE

Director, Office of Environmental Quality, 14th and Independence Avenue SW., Washington, D.C. 20250 (202) 447–3965

Animal and Plant Health Inspection Service

Office of the Administrator, Room 2137 South Agriculture Bldg., Washington, D.C. 20250 (202) 447–2996

Agriculture Stabilization and Conservation Service

Director, Conservation and Environmental Protection Division, Room 3096 South Agriculture Bldg., Washington, D.C. 20250 (202) 447–6221

Farmers Home Administration

Director, Environmental and Technology Staff, Room 6309 South Agriculture Bldg., Washington, D.C. 20250 (202) 447–3394

Food Safety and Quality Service

Room 611 Annex Bldg., Washington, D.C. 20250 (202) 447–7745

Forest Service

Environmental Coordinator, Room 3210 South Agriculture Bldg., P.O. Box 2417, Washington, D.C. 20250 (202) 447–4708

Rural Electrification Administration

Environmental and Energy Requirements Division, Room 3860 South Agriculture Bldg., Department of Agriculture, Washington, D.C. 20250 (202) 447–3228

Science and Education Administration

Room 20, Bldg. 005–BARC–W, Beltsville, Md. 20705 (301) 344–2198

Soil Conservation Service

Environmental Services Division, Room 6015 South Agriculture Bldg., P.O. Box 2890, Washington, D.C. 20013 (202) 447–3839

APPALACHIAN REGIONAL COUNCIL

Division of Energy, Environment and Natural Resources, 1666 Connecticut Avenue NW., Washington, D.C. 20235 (202) 673–7861

ARMS CONTROL DISARMAMENT AGENCY

Office of the General Counpsel, Room 5534, 320 21st Street NW., Washington, D.C. 20451 (202) 632–0767

CENTRAL INTELLIGENCE AGENCY

Director of Logistics, Room 2CO2 Page Bldg., 803 Follin Lane, Vienna, Va. 22180 (703) 281–8200

CIVIL AERONAUTICS BOARD

Chief, Environmental Programs Division (B–89), 1825 Connecticut Avenue NW., Washington, D.C. 20428 (202) 673–6089

DEPARTMENT OF COMMERCE

Office of Regulatory Policy, Environmental and Technical Evaluation Division, Room 3425 Commerce Bldg., Washington, D.C. 20230 (202) 377–4335

Economic Development Administration

Special Assistant for the Environment, Room 7217 Main Commerce Bldg., Washington, D.C. 20230 (202) 377–4208

Maritime Administration

Division of Environmental Activities, Department of Commerce, Washington, D.C. 20230 (202) 377–5136

National Oceanic and Atmospheric Administration

Office of Ecology and Conservation, Department of Commerce, Room 5811 Commerce Bldg., Washington, D.C. 20230 (202) 377–5181

COMMUNITY SERVICE ADMINISTRATION

Office of Public Affairs, Room 540, 1200 19th Street NW., Washington, D.C. 20506 (202) 254–5150

CONSUMER PRODUCT SAFETY COMMISSION

Office of the Executive Director, Room 528, 1111 18th Street NW., Washington, D.C. 20207 (202) 634–7770

DEPARTMENT OF DEFENSE

Office of Assistant Secretary of Defense (Energy, Environment and Safety), Room 3D833 The Pentagon, Washington, D.C. 20301 (202) 695–7820

Department of the Air Force

Deputy for Environment and Safety, Office of the Secretary, Room 4C885 The Pentagon, Washington, D.C. 20301 (202) 697–9297

Department of the Army

Army Environmental Office, H2DA(DAEN2CE), Room 1E676 The Pentagon, Washington, D.C. 20301 (202) 694–3434

Corps of Engineers

Executive Director of Civil Works, Office of the Chief of Engineers, Washington. D.C. 20314 (202) 272–0101

Defense Logistics Agency

Installation Services and Environmental Protection (DLA–W), Defense Logistics Agency, Cameron Station, Alexandria, Va. 22314 (703) 274–6967

Department of the Navy

Environmental Protection Office, Office of the Chief of Naval Operations, Room BC 766 The Pentagon, Washington, D.C. 20350 (202) 695–3639/89

Delaware River Basin Commission

Office of the Commissioner, Room 5113, 1100 L Street NW., Washington, D.C. 20240 (202) 343–5761

DEPARTMENT OF ENERGY

NEPA Affairs Division, Room 4G064, 1000 Independence Avenue SW., Washington, D.C. 20585 (202) 252–4600

Federal Energy Regulatory Commission

Advisor on Environmental Affairs, Room 3347, 825 North Capitol Street NE., Washington, D.C. 20460 (202) 357–8228

ENVIRONMENTAL PROTECTION AGENCY

Director, Office of Environmental Review, Room 2119 Mall, 401 M Street SW., Washington, D.C. 20460 (202) 755–0777

EXPORT-IMPORT BANK OF THE UNITED STATES

Office of General Counsel, Room 947 Lafayette Bldg., 811 Vermont Avenue NW., Washington, D.C. 20571 (202) 566–8334

FARM CREDIT ADMINISTRATION

Governor's Office, 490 L'Enfant Plaza East SW., Washington, D.C. 20587 (202) 755–2130

FEDERAL COMMUNICATIONS COMMISSION

Office of General Counsel, Room 616, 1919 M Street NW., Washington, D.C. 20554 (202) 632–6990

FEDERAL DEPOSIT INSURANCE CORPORATION

Office of the Comptroller, Room 4006A, 550 17th Street NW., Washington, D.C. 20429 (202) 389–4481

FEDERAL EMERGENCY MANAGEMENT AGENCY

Office of General Counsel, 1725 I Street NW., Washington, D.C. 20472 (202) 634–4100

FEDERAL HOME LOAN BANK BOARD

Office of General Counsel, Third Floor, East Wing, 1700 G Street NW., Washington, D.C. 20552 (202) 377–6404

FEDERAL MARITIME COMMISSION

Director, Office of Environmental Analysis, 1100 L Street NW., Washington, D.C. 20573 (202) 523–5835

FEDERAL RESERVE SYSTEM

Secretary of the Board of Governors of the Federal Reserve, 20th and Constitution Avenue NW., Washington, D.C. 20551 (202) 452–3252

FEDERAL SAVINGS AND LOAN INSURANCE CORPORATION

1700 G Street NW., Washington, D.C. 20552 (202) 377–6000

FEDERAL TRADE COMMISSION

Office of General Counsel, Room 588, Pennsylvania Avenue at 6th Street NW., Washington, D.C. 20580 (202) 523–1928

GENERAL SERVICES ADMINISTRATION

Office of Space Management, Room 2341, 18th and F Streets NW., Washington, D.C. 20405 (202) 566–1416

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Office of Environmental Affairs, Management and Budget, Room 537F Hubert H. Humphrey Bldg., 200 Independence Avenue SW., Washington, D.C. 20201 (202) 472–9740

Center for Disease Control

Chief, Environmental Affairs Group, Environmental Health Services Division, Bureau of State Services, Room E511, 600 Clifton Rd., Atlanta, Ga. 30333 (404) 262–6641

Food and Drug Administration

Environmental Impact Staff HFV–2/HFV–9, Food and Drug Administration, 5600 Fishers Lane, Rockville, Md. 20857 (301) 443–4501

Health Services Administration

Agency Environmental Officer, Room 13–31 Parklawn Bldg., 5600 Fishers Lane, Rockville, Md. 20857 (301) 472–9740

National Institutes of Health

Deputy Director for Environmental Health and Safety, Division of Safety, Room 4051 Building 12A, 9000 Rockville Pike, Bethesda, Md. 20205 (301) 496–1985

Office of Human Development Services

Director, Office of Policy and Management Control, Room 302E Hubert H. Humphrey Bldg., 200 Independence Avenue SW., Washington, D.C. 20201 (202) 245–6275

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Office of Environmental Quality, Room 7276 HUD Bldg., 451 7th Street SW., Washington, D.C. 20410 (202) 755–6300

DEPARTMENT OF THE INTERIOR

Office of Environmental Project Review, Room 4256 18th and C Streets NW., Washington D.C. 20240 (202) 343–3891

Bureau of Indian Affairs

Environmental Services Staff (204), Department of the Interior, Room 4550, 18th and C Streets NW., Washington, D.C. 20245 (202) 343–4004

Bureau of Land Management

Office of Planning, Inventory and Environmental Coordination (202), Department of the Interior, Room 412 Board of Trade Bldg., 1129 20th Street NW., Washington, D.C. 20240 (202) 343–7417

Bureau of Mines

Special Assistant for Environmental Assessment, Department of the Interior, Room 1004 Columbia Plaza Bldg., 2401 E Street NW., Washington, D.C. 20506 (202) 634–1310

Fish and Wildlife Service

Office of Environmental Coordination, Department of the Interior, 18th and C Streets, NW., Washington, D.C. 20240 (202) 343–5685

Geological Survey

Environmental Affairs Office (MS–760), Department of the Interior, Room 2D234 National Center, Reston, Va. 22092 (703) 860–7455, 7456

Heritage Conservation and Recreation Service (formerly Bureau of Outdoor Recreation)

Division of Environmental Compliance and Review, Room 337 Pension Bldg., 440 G Street NW., Washington, D.C. 20243 (202) 343–7962

National Park Service

Office of Environmental Compliance and Planning, Department of the Interior, Room 1210, 18th and C Streets NW., Washington, D.C. 20240 (202) 343–2163

Office of Minerals Policy and Research Analysis

Energy and Minerals Program Analysis, Room 4455, 18th and C Streets NW., Washington, D.C. 20240 (202) 343–8567

Office of Surface Mining Reclamation and Enforcement

Branch of Environmental Analysis, Department of the Interior, Room 5310, 1100 L Street NW., Washington, D.C. 20240 (202) 343–5287

Office of Water Research and Technology

Interagency Water Research Coordination, Department of the Interior, Room 4112, 18th and C Streets NW., Washington, D.C. 20240 202 343–8092

Water and Power Resources Service (formerly Bureau of Reclamation)

Office of Environmental Affairs, Department of the Interior, Room 7622 18th and C Streets NW., Washington, D.C. 20240 (202) 343–4991

INTERNATIONAL BOUNDARY AND WATER COMMISSION, U.S. SECTION

IBW Bldg., 4110 Rio Bravo, El Paso, Tex. 79902 (FTS) 572–7393

INTERNATIONAL COMMUNICATION AGENCY

Office of General Counsel, Room 917, 1750 Pennsylvania Avenue NW., Washington, D.C. 20547 (202) 724–9054

INTERSTATE COMMERCE COMMISSION

Section of Energy and Environment, Room 3371, 12th and Constitution Avenue NW., Washington, D.C. 20423 (202) 275–7658

DEPARTMENT OF JUSTICE

General Litigation Section, Land and Natural Resources Division, Room 2127 Justice Bldg., 9th and Pennsylvania Avenue NW., Washington, D.C. 20530 (202) 633–2704

Bureau of Prisons

Office of Facilities Development and Operations, Department of Justice, 320 1st Street NW., Washington, D.C. 20534 (202) 724–3234

Drug Enforcement Administration

Office of Science and Technology, Department of Justice, 1405 I Street NW., Washington, D.C. 20537 (202) 633–1211

Immigration and Naturalization Service

Facilities and Engineering Branch, Department of Justice, 425 I Street NW., Washington, D.C. 20536 (202) 633–2648

National Institute of Justice

Environmental Coordinator, Department of Justice, Washington, D.C. 20530 (301) 492–9094

Office of Justice, Assistance, Research and Statistics (formerly LEAA)

Environmental Coordinator, Room 1154, 633 Indiana Avenue NW., Washington, D.C. 20531 (202) 724–7659

DEPARTMENT OF LABOR

Office of Health and Disability, Room S–2121, 200 Constitution Avenue NW., Washington, D.C. 20210 (202) 523–6094

Mine Safety and Health Administration

Office of Standards, 4015 Wilson Blvd., Arlington, Va. 22032 (703) 235–1910

Occupational Safety and Health Administration

Room N–3651 Labor Bldg., 200 Constitution Avenue NW., Washington, D.C. 20210 (202) 523–7056

MARINE MAMMAL COMMISSION

General Counsel, Room 307, 1625 Eye Street NW., Washington, D.C. 20006 (202) 653–6237

NATIONAL ACADEMY OF ENGINEERING

Room JH 804, 2101 Constitution Avenue NW., Washington, D.C. 20418 (202) 389–6864

NATIONAL ACADEMY OF SCIENCES

Room JH 804, 2101 Constitution Avenue NW., Washington, D.C. 20418 (202) 389–6864

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Management Support Office (External Relations), Code LB–4, Room 6133, 400 Maryland Avenue SW., Washington, D.C. 20546 (202) 755–8383

NATIONAL CAPITAL PLANNING COMMISSION

Environment/Energy Branch, Room 1040, 1325 G Street NW., Washington, D.C. 20576 (202) 724–0180

NATIONAL CREDIT UNION ADMINISTRATION

Office of General Counsel, 1776 G Street NW., Washington, D.C. 20456 (202) 357–1030

NATIONAL SCIENCE FOUNDATION

Assistant Director, Astronomical, Atmospheric, Earth and Ocean Sciences, 1800 G Street NW., Washington, D.C. 20550 (202) 357–9715

NUCLEAR REGULATORY COMMISSION

Division of Site Safety and Environmental Analysis, Room P518A, Phillips Bldg., 7920 Norfolk Avenue, Bethesda, Md. 20014 (301) 492–8446

OVERSEAS PRIVATE INVESTMENT CORPORATION

General Counsel's Office, Room 725, 1129 20th Street NW., Washington, D.C. 20527 (202) 632–1796

PENNSYLVANIA AVENUE DEVELOPMENT CORPORATION

Office of Long Range Planning, Suite 1148, 425 13th Street NW., Washington, D.C. 20004 (202) 566–1218

SECURITIES AND EXCHANGE COMMISSION

Office of General Counsel, Room 2327 L, 500 North Capitol Street NE., Washington, D.C. 20549 (202) 523–2350

SMALL BUSINESS ADMINISTRATION

Office of Financing, Room 800, 1441 L Street NW., Washington, D.C., 20416 (202) 653–6696

SMITHSONIAN INSTITUTION

General Counsel, 1000 Jefferson Drive SW., Washington, D.C. 20560 (202) 628–4422

DEPARTMENT OF STATE

Office of Environmental Affairs, Room 7820 State Department Bldg., 21st and C Streets NW., Washington, D.C. 20520 (202) 632–9266

Agency for International Development

Room 3245, State Department Bldg., 2201 C Street NW., Washington, D.C. 20523 (202) 632–1036

SUSQUEHANNA RIVER BASIN COMMISSION

Office of the Commissioner, 1100 L Street NW., Room 5113, Washington, D.C. 20240 (202) 343–4091

TENNESSEE VALLEY AUTHORITY

Environmental Quality Staff, Natural Resources Bldg., Norris, Tenn. 37828 (615) 494–9800/(FTS) 856–6450

DEPARTMENT OF TRANSPORTATION

Office of Environment and Safety, Room 9322 Nassif Bldg., 400 7th Street SW., Washington, D.C. 20590 (202) 426–4357

United States Coast Guard

Office of Marine Environment and Systems (G–WS–1), 2100 2d Street SW., Washington, D.C. 20593 (202) 426–3300

Federal Aviation Administration

Office of Environment and Energy, Room 939 FOB–10A, 800 Independence Avenue SW., Washington, D.C. 20591 (202) 426–8406

Federal Highway Administration

Office of Environmental Policy, Room 322 Nassif Bldg., 400 7th Street SW., Washington, D.C. 20590 (202) 426–0106

Federal Railroad Administration

Office of Policy and Program Development, Room 5100 Nassif Bldg., 400 7th Street SW., Washington, D.C. 20590 (202) 426–9684

National Highway Traffic Safety Administration

Office of the Chief Counsel, 400 7th Street SW., Washington, D.C. 20590 (202) 426–2992

St. Lawrence Seaway Development Corp.

Office of Comprehensive Planning, 800 Independence Avenue SW., Washington, D.C. 20591 (202) 426–9755

Urban Mass Transit Administration

Office of Program Analysis, Room 9305 Nassif Bldg., 400 7th Street SW., Washington, D.C. 20590 (202) 472-2435

DEPARTMENT OF THE TREASURY

Room 706 Treasury Bldg., 1331 G Street NW., Washington, D.C. 20220 (202) 376–0289

UNITED STATES POSTAL SERVICE

Director, Office of Program Planning, Room 8915, 475 L'Enfant Plaza SW., Washington, D.C. 20260 (202) 245–4304

VETERANS ADMINISTRATION

Office of Environmental Affairs, Code 003A, 810 Vermont Avenue NW., Washington, D.C. 20420 (202) 380–2526/2529

WATER RESOURCES COUNCIL

Policy Analysis Division, Suite 800, 2120 L Street NW., Washington, D.C. 20037 (202) 254–6453

Great Lakes Basin Commission

Office of the Chairman, P.O. Box 999, 2475 Plymouth Road, Ann Arbor, Mich. 48106 (313) 668–2333

Missouri River Basin Commission

Office of the Chairman, Suite 403, 10050 Regency Circle, Omaha, Neb. 68114 (406) 449–2876

New England River Basin Commission

Office of the Chairman, 53 State Street, First Floor, Boston, Mass. 02109 (617) 223–6244

Ohio River Basin Commission

Office of the Chairman, Suite 208–220, 36 East 4th Street, Cincinnati, Ohio 45202 (513) 684–3831

Pacific Northwest River Basins Commission

Office of the Chairman, P.O. Box 908, One Columbia River, Vancouver, Washington 98660 (206) 694–2581

Upper Mississippi River Basin Commission

Office of the Chairman, Room 510, Federal Office Bldg., Fort Snelling, Twin Cities, Minnesota 55111 (612) 725–4690

APPENDIX G

MEMBERS AND STAFF OF THE COUNCIL ON ENVIRONMENTAL QUALITY *

MEMBERS

Gus Speth, *Chairman*
Jane H. Yarn, *Member*
Robert H. Harris, *Member*

STAFF

Edward L. Strohbehn, Jr. *Executive Director*
Nicholas C. Yost *General Counsel*
Patricia Adams
Julia Alessio
Bryan H. Baas
Malcolm F. Baldwin
Carroll Leslie Bastian
Janet L. Bearden
Charles M. Benbrook
Barbara J. Bramble
Doris J. Brown
Gerald L. Brubaker
John D. Buffington
David E. Burmaster
Joan F. Carmichael
Bernice J. Carney
Donna L. Clark
John A. Davidson
Marinda T. Davis
Thomas J. Delaney
Odelia L. Doggette
Katherine B. Gillman
Margaret M. Gugino
Jean M. Halloran
Kenneth J. Hood
Caroline Isber
Michael J. Kane
C. Foster Knight
Larry Liebesman
Mary Lou Lucas
James W. Lund
James J. MacKenzie
Roger E. McManus
Paul Milvy
Muriel L. Montgomery
Sheila A. Mulvihill
Robert B. Nicholas
Elliott A. Norse
Charles A. Osolin
Paul R. Portney
David Ritersbacher
Joan M. Russo
Don G. Scroggin
Denise C. Seward
John F. Shea, III
Robert B. Smythe
Grace R. Sorel
Elizabeth E. Stewart
Rita Tehan
Kenneth S. Weiner
M. Gayle Wilkins
Lawrence F. Williams
Kung-Wei Yeh
Charles F. Zimmermann

INTERNS AND STUDENTS

Susan Alexander
Brenda Butler
Lisa Carty
Ann Durant
Bonnie Holmes
Terry Hunter
Judith Ingram
Ann Jones
David Junious
William Kemp
Ronald Klein
Beth Koening
Jane Marans
Frances McChesney
Colleen Prendergast
Barbara Sih
Patrick Weadon
Linda Weissinger
Leslie Woodruff

* As of July 1980; includes temporary employees and employees on detail from other federal agencies.

INDEX

A

Abalone, 66
  Accuracy of estimates, 396–99
Abatement costs
  Cost-benefit analysis and the courts, 392–93
  Estimated incremental expenditures, 1979–88, 394
  Estimated total expenditures, 1979–88, 397
  Expenditures on, 393–99
  Extent of, 387–89
  Incentives for, 389–92
  Ratio of estimated to actual expenditures in selected industries, 399
Acetone, 97
Acid Precipitation Task Force, 177
Acid rain, 4, 173–77, 283
Acid Rain Coordination Committee, 176, 177
Agency for International Development, 26–27
Agent Orange, 223
Agreement on the Conservation of Polar Bears, 72
Agriculture
  Acres eroding, four major crops, 313
  Average annual precipitation, 347
  Biological diversity and, 48
  Energy production from, 316–20
  Essential plant nutrients lost, 319
  Management practices, 311–16
  Plant nutrients in crop residues, 317
  Soil erosion, 311–16
Agriculture—Continued
  Soil erosion in the central states, 314
  Trends, 360–64
  Water pollution and, 133
Agriculture Department, 52, 63, 69, 302, 312–16, 320, 323, 361, 363
Air quality
  Annual arithmetic average of daily maximum 8-hour CO concentrations 1973–78, 166
  Annual arithmetic mean of 24-hour average SO_2 concentrations, 1973–78, 167
  Annual geometric mean of average TSP concentrations, 1973–78, 168
  Composite average concentrations of benzo(a)pyrene for 26 urban sites, 1966–77, 179
  Composite average concentrations of benzo(a)pyrene with and without coke ovens for 26 urban sites, 1966–77, 180
  Costs of, 395
  Emissions trends, 169–71
  Estimated national exposures to pollutants above the short-term ambient health-related standards, 1978, 159
  Federal air pollution control regions, 161
  Incentive programs, 390–92
  Indoor air quality, 183–88
  National Ambient Air Quality Standards, 171–73
  National emissions standards for hazardous air pollutants, 177

Air quality—Continued
National trends in urban PSI levels, 1974–78, 152
Urban trends, 147
PSI, 154–58
Ranking of 40 SMSAs using the PSI, 1976–78, 154
Regional air quality, 158–62
State Implementation Plans, 183
Trends, 179–83
Trends in ambient concentrations, 163–68
Trends in PSI levels in 23 SMSAs, 1974–78, 148
See also Acid rain.
Aircraft, 278
Alabama, 284
Alaska, 280, 295, 298–300, 378, 380
Alaska Coalition, 299
Alaska National Interest Lands Conservation Act, 299
Alaska Native Claims Settlement Act of 1971, 298
Alaska Statehood Act, 298
Alewives, 46, 109
Amazonian rubber tree, 36
American alligator, 70
American chestnut, 62
American Civil Liberties Union, 205
American Cyanamid, 205
American mastodon, 41
American Petroleum Institute, 393
Amtrak Improvement Act of 1978, 383
Anabaena azollae, 35
Andrus v. *Sierra Club*, 378
Antarctic krill, 41
Antarctic Treaty, 72
Antioch Dunes, 48, 62
Antiquities Act of 1906, 299
Arctic Wildlife Range, 299, 300
Arizona, 297, 339
Arkansas, 110
Army Corps of Engineers, 16, 325, 327
Arsenic, 89, 116, 177
Asbestos, 177, 224, 227
Ashland Oil, 316
Asian grass carp, 64
Asian winged bean, 35
Atlanta Coalition on Transportation v. *Atlanta Regional Commission*, 381
Atlantic City, 345
Aurora trout, 56
Australia, 11
Australian cycad, 58
Azolla pinnata, 35
Aztec cactus, 58

B

Bald eagle, 67
Bangladesh, 10
Barley, 33, 34
Barrington, R.I., 124
Barro Colorado Island, 45
Baxter County, Ark., 191
Beaufort Sea, 380
Bedford, Mass., 96
Belgium, 15, 290
Benzene, 89, 90, 177, 393
Benzo(a)pyrene, 178–80
Big Cypress Swamp, 68
Bighorn sheep, 47
Biological diversity
Agriculture and, 48
Areas of exceptional genetic diversity for crop plants, 50
Benefits of, 32–38
Chemicals and, 56–57
Conservation of, 64–69
Ecosystem approach, 67–69, 73
Forests and, 52–56
Gene banks, 64–65
Human reduction of, 40–43
Human settlement and, 43–44
Introduction of exotic species, 61–64
Land and sea use and, 43–55
Number of species and island size, 45
Psychological and philosophical basis of, 38–40
Selected plants and animals affected by excessive harvest, 59–60
Species approach, 66–67
Transportation and, 44–48
U.S. policies on, 69–71
Wild species and, 57–61
Biomass. *See* Energy.
Bis (2-ethylhexyl), 96
Bison, 66
Black Lung Benefits Reform Act, 223, 226
Black rat, 61
Blackfooted ferret, 58
Blackfooted penguin, 56
BLM. *See* Land Management Bureau of.
Blue crabs, 108
Blue whale, 67
Brazil, 54
Brown pelican, 56
Bruceantin, 37
Bridger-Teton National Forest, 285
Bryce Canyon National Park, 301
Bufadienolides, 39

Buffalo, N.Y., 153
Burros, 63

C

Cabbage butterfly, 62
Cactus, 66
Cadmium, 105–108, 116
Caffeine, 191, 210–12
California
  Ambient air concentrations, 163–65, 167–69
  Ground water contamination, 82
  Mercury pollution, 109
  Nonpoint water pollution, 134
  Ozone, 164, 166
  Population, 339, 345
  Septic tank pollution, 89
California condor, 66
California Desert, 308, 309
California Public Utility Commission, 255
California v. *Bergland*, 305, 376, 377
Campeche Bay, 21
Canada, 13, 25–26
Cancer
  Age-adjusted cancer death rates, 1930–77, 196
  Air quality and, 178
  Drinking water and, 86
  Ozone depletion and, 13
  Toxic substances and, 192–95
Carbon dioxide, 4, 12, 265–67
Carbon Dioxide Effects Research and Assessment Program, 266–67
Carbon monoxide, 153
Carbon tetrachloride, 86, 95
Caribou, 24, 52
Carolina parakeet, 58
Carson, Rachel, 40, 56
Carter, Jimmy
  Acid rain, 283
  Alaska, 299
  Energy Message, 1979, 280
  Environmental Message of 1977, 120
  Environmental Message of 1979, 8, 307, 309
  Forest management, 302–303
  Global 2000 Report, 2
  Mexican efforts on environment, 26
  Radioactive waste management, 288
  Soil Conservation Service and, 359
  Three Mile Island, 286–88
  Urban Initiative, 136
  Water Policy Message, 325
  Wild and Scenic Rivers, 302
Carslbad, N. Mex., 289
Center for Disease Control, 209
Central Arizona Project, 351
Central Valley, 352
Central Valley Project of California, 351
Channel Islands, 62
Channel Islands National Park, 301, 302
Chemical Industry Institute of Toxicology, 185
Chemical Manufacturers Association, 239, 240
Chemicals, 56–57, 198
  Annual production of synthetic organic chemicals 1920–78, 198
Chestnut blight fungus, 62
Chicago, 147, 153
Chile, 222
Chlorinated benzene, 235
Chlorinated phenols, 89
Chloromethane, 235
CITES. *See* Convention on International Trade in Endangered Species of Wild Fauna and Flora.
Citizens for Responsible Growth v. *Adams*, 378
Citizens To Preserve Overton Park v. *Volpe*, 376
Civil Aeronautics Board, 383
Clean Air Act, 390–92
Clean Water Act of 1977, 123, 127, 132, 327
Cleveland, Grover, 296
Climate, 15
Coal, 259, 262, 283–85
Codium fragile, 62
Codling moth, 62
Colorado, 284, 345, 358
Columbia River Basin, 324, 359
Commerce Department, 69
Community Development Block Grant Program, 383
Connecticut, 110
Conservation
  Costs of, 322–24
  Incentives, 320–21
  Integrated pest management, 321–24
  Protection of environmentally critical areas, 382
Conservation Agricultural Program, 358
Consumer Product Safety Commission, 185–86
Convention Concerning the Protection of the World Cultural and Natural Heritage, 72

Convention for the Protection of Migratory Birds, 72
Convention on International Trade in Endangered Species of Wild Fauna and Flora, 70–72
Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, 70
Cookes kokio, 65
Copper, 116
Corn leaf blight, 51
Costa Rica, 9, 11, 54
Council on Environmental Quality, 331, 371, 373, 374, 393–99
Crabgrass, 62
Crater Lake, 307
Cyanide, 89, 110

D

Dandelions, 46
Dark-rumped petrel, 61
Dawn mollusc, 57
DDT, 56, 114
Defenders of Wildlife v. *Andrus*, 377, 378
Deforestation, 3, 7–12
Delaware, 326
Denmark, 185
Denver, 153
Desert Land Act of 1877, 295
Desertification, 3–4, 346–60
Di (n-butyl) phthalate, 96
Dickens, Charles, 206
Dieldrin, 114
Diesel fuel, 191, 212–14
Dimethyl sulfide, 97
Dioxin, 202
Dipterocarps, 55
Douglas fir, 53
Dusky seaside sparrow, 66

E

Ebony, 53
Economic Commission for Latin America, 27
Economic Development Administration, 378
Ehrenfeld, David, 39, 40
Ehrlich, Paul, 49
Electricity, 261
Elton, Charles S., 40
Endangered species, 70
Endangered Species Act, 40, 69–71 327, 380
Endangered Species List, 67, 327
Endrin, 86
Energy
  Biological diversity and, 35–36
Energy—Continued
  Biomass, 261, 267–74, 316–20
  Consumption forecasts, 2000, 257
  Consumption per GNP dollar, 1973–79, 257
  Domestic imports of, 262
  Electric utility trends, 261
  Federal solar and energy programs, 252
  Fossil fuel issues, 279–85
Gasohol, 316
  Ground water contamination and, 91
  Growth rates and share of energy consumption source, 1979, 259
  Hydrogen, energy carrier, 276–79
  Imports by source, 1973–79, 263
  Legislative initiatives, 262–65
  NEPA decisions, 379–82
  Nuclear issues, 286–90
  Production by source, 1973–79, 262
  Programs to encourage efficiency, 253, 255
  Renewable technologies, 255
  Total consumption, 1979, 256, 258, 259
  U.S. gross consumption, 1900–79, 259
  Utility Oil Back-Out Program, 281–83
  Wind farms, 255
  Windfall profit tax, 264
Energy Department, 184, 213, 264–65
  Energy Information Administration, 260
Energy Mobilization Board, 263
Energy Research and Development Administration, 381
Energy Security Act, 264
Energy Security Corporation, 263–64
Environmental Defense Fund, 301
Environmental Emergency Response Act, 230
Environmental Impact Statements. *See* National Environmental Policy Act.
Environmental Protection Agency
  Accuracy of estimating abatement costs, 396–99
  Air quality enforcement actions, 1977–79, 182
  Air quality incentive programs, 390
  Alternative technologies, 124–26
  Bubble and offset policies, 390
  Clean Lakes Program, 136–38

Environmental Protection Agency—Continued
Diesel exhaust, 213
Effluent guidelines program, 126–28
Ground water surveys, 83
Hazardous wastes disposal, 214–22
Hazardous wastes list, 216, 217
National Aerometric Data Bank, 147
National Air Monitoring Sites, 158
National Interim Primary Drinking Water Regulations, 116, 118
National Pollutant Discharge Elimination System permits, 130–32, 371–73
Nationwide Urban Runoff Program, 135
NEPA study, 371–73
Ocean dumping permits, 16
Office of Radiation Programs, 186–87
Ozone, 13
Permit consolidation, 132
Pretreatment programs, 128–30
Seven Lakes, 137–38
Solid waste management, 122–26
Suggested No Adverse Response Level, 87
STORET, 115
Surface Impoundment Assessment, 88–89, 91
Toxic substances testing, 232–40
Water Quality Management Program, 135
Water quality monitoring, 120, 122
Water regulation, 86–87
Euphorbia spp., 35
European Economic Community, 13, 20
Everglades, 68
Executive Order on Exotic Organisms, 64
Export Administration Act, 222, 241

F

Falmouth Co-op Co., 229
Farm Bureau Services, Inc., 229
Farmers Home Administration, 378
Federal Acid Rain Assessment Program, 176
Federal Aviation Administration, 378
Federal Committee on Ecological Reserves, 73
Federal Disaster Relief Act, 221
Federal Emergency Management Agency, 287
Federal Employers' Liability Act, 226
Federal Great Plains Conservation Program, 358–59
Federal Highway Administration, 379
Federal Insecticide, Fungicide and Rodenticide Act, 232, 395
Federal Land Policy and Management Act of 1976, 297, 299, 307–309, 382
Federal Property and Administrative Services Act, 382
Federal Railroad Administration, 383
Federal Water Pollution Control Act, 97–98, 122
Federation of American Societies for Experimental Biology, 210
Feral goats, 63
Ficklin, Orlando B., 295
Fish and Wildlife Coordination Act, 325
Florida, 43, 326, 339, 345
Florida manatees, 48
Flower Garden Banks, 57, 281
Food, 3, 7, 34–35
Food and Drug Administration, 208, 210, 211
Forest and Rangeland Renewable Resources Planning Act of 1974, 297, 302, 309
Forest Service, 303, 304, 305, 331, 373
Forests
Biological diversity and, 52–56
Disappearance of, 3
Integrated pest management, 305
Management of, 302–304
Mining in, 382
See also Deforestation.
Formaldehyde, 185, 186, 187
France, 232
Freon, 97
Friends of the Earth, 301
Furbish louseworts, 33, 67

G

Gaines County, Tex., 360
Gaithersburg, Md., 134
Galapagos Islands, 35
Galveston Harbor, 20
Gartiot County, Mich., 191
Gassville, Ark., 215
Gatun Lake, 46
General Accounting Office, 133, 182, 301, 324, 357

General Mining Law of 1872, 295
General Revision Act of 1891, 295
General Services Administration, 382
Georges Bank, 380
Georgia, 345
Giant kelp, 35
Giant Siberian crane, 68
Gifford Pinchot National Forest, 306, 382
Gila trout, 43
Glacier Bay National Monument, 300
Global 2000 Report to the President, 1–5
Goshawks, 48
Grand Canyon National Park, 300
Grand Rapids, Mich., 153
Gray, Maine, 96, 97
Gray whale, 66
Gray wolf, 58
Grazing Fields Farm v. *Goldschmidt*, 379
Great Britain, 15
Great Lakes Water Quality Agreement, 112–14
Great Plains Conservation Program, 359
Green Revolution, 51
Green sea turtle, 35, 48
Grey squirrels, 48
Groveland, Mass., 82
Guatemala, 51
Guayule, 36

H

Haiti, 222
Hanford, Wash., 381
Harpers Ferry National Historical Park, 301
Hawaii, 62, 255
Hazardous wastes
  Compensation of victims, 223–30
  Congressional report on, 216
  Discovery of dumpsites, 214
  Disposal costs, 219
  Disposal options, 216–20
  Enforcement of regulations, 220–21
  Export of, 221–22
  List of, 216, 217
  See also Toxic substances.
Helminthosporium maydis, 51
Heritage Conservation and Recreation Service, 124, 301, 373
Herring, 109
Herring gulls, 114
Hickory, 53
Homestead Act of 1862, 295
Hooker Chemical Co., 221, 223, 392
Horseshoe crab, 34
House sparrow, 62, 63
Housing and Urban Development Department, 210, 264, 364, 375, 383
Houston, 147
Houston toad, 39
Humpback whale, 67
Hunger. *See* Food.
Hurricane David, 345
Hurricane Frederick, 345
Hyattsville, Md., 124

I

Idaho, 309
Illinois, 362, 363
Illinois Natural History Survey, 133
Independent Offices Appropriation Act, 382
India, 10, 68
Indian mongoose, 61
Indian wasp, 35
Indonesia, 10
Industrial Union Department, AFL-CIO v. *American Petroleum Institute et al.*, 392–93
Integrated pest management, 304–305
Integrated Pest Management Coordinating Committee, 321
Interagency Task Force on Tropical Forests, 5, 8, 10, 11
Interagency Testing Committee, 236
Inter-Governmental Maritime Consultative Organization, 21–22
Interim Convention for Conservation of North Pacific Fur Seals, 72
Interior Department, 63, 69, 99, 280, 281, 296, 325, 331, 382–83
Internal Revenue Service, 365
International Atomic Energy Agency, 18
International Boundary and Water Commission, 26
International Conference on Tanker Safety and Pollution Prevention, 21
International Convention for the Regulation of Whaling, 72
International Council of Scientific Unions, 12, 267
International Energy Agency, 267
International Joint Commission, 25, 112

International Nuclear Fuel Cycle Evaluation, 289–90
International Union for the Conservation of Nature and Natural Resources, 1, 72, 73
International Whaling Commission, 22–24
Inupiats 23, 381
Iowa, 49
Ireland, 51
Israel, 37
Ivory Coast, 9
Ivory-billed woodpecker, 53

J

Jackson Township, N.J., 223
Jaguars, 65
Japan, 15, 229
Johns-Manville, 223
Jojoba, 36–37
Justice Department, 220, 221

K

Kansas, 360
Kansas City, 147
Kemeny, John G., 286
Kemp's Ridley sea turtle, 58, 61
Kenaf, 37
Kenya, 37, 51
Kepone, 111, 202
Kleppe v. *Sierra Club*, 375–76
Kudzu, 46, 62

L

Labor Department, 225–27, 230
Labor Statistics, Bureau of, 398
Lakes, 136–38
Lake Baikal, 307
Lake Tahoe, 307
Lake Tahoe Federal Coordinating Council, 307
Lake Titicaca Basin, 49
Lake trout, 114
Land Management, Bureau of, 281, 307–311, 331, 351
Land use
  Coastal areas and floodplains, 345–46
  Farming in ranch country, 357–59
  Human settlements and, 338
  Overgrazing, 349–51, 355–57
  Public lands, growth and development, 294–98
  Salinity, 352–57
  Scarcity of water and, 359–60
  Sludge reclamation, 126
Land use—Continued
  Special management systems, growth of, 1969–79, 298
  Tax policy and, 365
  Transportation policy and, 365
  Trends, 338
  Urbanization and, 357, 364–66
Largemouth bass, 66
Law of the Sea Conference, 22
Lawrence Berkeley Laboratory, 184, 185
Laysan Island, 62
Lead, 105–108, 116, 206–10
Lead-Based Paint Poisoning Prevention Act, 210
Lebanon, N.H., 378
Legler, N.J., 191, 214, 215
Lemurs, 65
Leopold, Aldo, 39, 40
Leucaena leucocephala, 35
Liberia, 222
Lindane, 86
London Ocean Dumping Convention of 1972, 15, 16, 18
Longleaf pine, 66
Longshoremen's and Harbor Workers' Compensation Act, 226
Lopez Portillo, 26
Los Angeles, 147, 153
Louisville, Ky., 147
Love Canal, 192, 214, 219–30
Lung diseases, 195–99, 200, 224

M

MacArthur, Robert, 44
Maine, 4
Malaysia, 10
Man and the Biosphere Program, 73
Management Framework Plans, 308
Marine Mammal Protection Act of 1972, 72
Marine Protection, Research and Sanctuaries Act, 16, 380
Marmosets, 65
Marshall, Thurgood, 375
Massachusetts, 255
Maytensine, 37
McGraw-Hill, 398
McKin Co., 97
Mediterranean fruitfly, 62
Mediterranean Sea, 20
Mellon Institute, 256
Menhaden, 36
Mercury, 105–108, 109–114, 177
Methoxychlor, 86
Methylene chloride, 90
Mexican bean beetle, 35

Mexico, 26, 222
Michigan, 110
Michigan Chemical Co., 215, 216, 229
Migratory Species Treaty, 73
Milkweed, 35
Mineral Leasing Act of 1920, 296
Mines and mining
  Abatement costs, 395
  Nonpoint water pollution, 134
  Overthrust Belt, 284
  Resource study, 330–32
Mines, Bureau of, 331–32
Mirex, 114, 202
Mississippi Power and Light Co. v. *NRC*, 382
Mobil Canal, 109
Monticello, Ark., 124
Moose, 52
Morris County, N.J., 124
Mosquito, 62
Mount St. Helens, 170, 306, 324
Mount St. Helens Timber Salvage and Mitigation Act, 306
Muir, John, 40
Multiple-Use Sustained-Yield Act of 1960, 297
Myers, Norman, 10

N

Nassau County, N.Y., 95–96
National Academy of Sciences, 9, 13, 54, 65, 207, 210, 266, 330–32
  Committee on Surface Mining and Reclamation (COSMAR), 330–32
National Agricultural Lands Study, 361
National Association of Conservation Districts, 361
National Cancer Institute, 37
National Commission on State Workmen's Compensation Laws, 227
National Environmental Policy Act
  Agencies most frequently sued under, 383–84
  Benefits of, 371–73
  Costs of EIS, 382–83
  Court actions, 1979, 374–76, 383–84
  Energy decisions, 379–82
  Evaluation of regulations, 371
  Motivation for, 40
  Radioactive waste management, 288
  Rangeland, 311
  Supplemental procedures, 370
National Forest Management Act of 1976, 297, 303, 309
National Historic Preservation Act, 325
National Historic Trails, 302
National Institute for Occupational Safety and Health, 195, 213, 230–31
National Marine Fisheries Service, 61
National Marine Mammal Laboratory, 24
National Oceanic and Atmospheric Administration, 281, 373
National Park System, 296, 297, 300–301
National Plan for Nuclear Waste Management, 289
National Railroad Passenger Corporation, 383
National Recreational Trails, 302
National Register of Historic Places, 373
National Research Trails, 302
National Resources Inventory of 1977, 313
National Science Foundation, 230
National Stream Quality Accounting Network, 100–102, 108
National Trails System, 302
National Wild and Scenic Rivers, 301–302
National Wilderness Preservation System, 305
Natural Resources Defense Council, 213, 214, 236, 239
Natural Resources Defense Council v. *Morton*, 310
Navy, 63
Nebraska, 360
Nedlog Corp., 222
Netherlands, 15, 185, 218
Nevada, 223, 297, 339
New England Power Company, 382
New England Power Co. v. *Goulding*, 382
Newell's shearwater, 61
New Hampshire, 108
New Jersey, 99–100, 108
New Mexico, 298, 349–51, 358, 363
New York City, 124, 147, 153, 209
New York Harbor, 16
New York Public Interest Research Group, 82
New York State, 95, 99–100, 110, 345
  Ground water monitoring, 95
New Zealand, 11

Nigeria, 222
Nonproliferation Alternative Systems Assessment Program, 290
North American Wildlife and Natural Resources Conference, 73
North Carolina, 345
North Country National Scenic Trail, 302
North Reading, Mass., 82
North Slope, 23
North Slope Borough v. *Andrus*, 380
Norway, 13
Norway rat, 61
NRDC v. *NRC*, 381
Nuclear nonproliferation, 289–90
Nuclear Regulatory Commission, 286–88, 373–74
Nuclear Safety Oversight Committee, 287

O

Oaks, 48
Ocean City, Md., 345
Ocean Dumping Act of 1972, 126
Oceans, 15–20
  Dumping, 15–20
Occidental Petroleum Corp., 221, 392
Occupational Safety and Health Administration, 185, 188, 205, 393
Off-road vehicles, 48, 357
  Decontrol of, 254
  International efforts to control pollution, 21–22
  Spills, 1979, 20–21
  World production of, 3
Oil, Chemical and Atomic Workers Union, 205, 216
Oil, Hazardous Substances, and Hazardous Waste Response Liability and Compensation Act, 222, 230
Oil shale, 91
Olin Corp., 221
Orchids, 66
Oregon, 134
Organization for Economic Cooperation and Development, 18, 19, 232, 234, 238, 267
Osceola National Forest, 331
Outer Continental Shelf Lands Act of 1978, 281, 379, 380
Outer Continental Shelf oil and gas, 279–81
Overthrust Belt, 284, 285
Ozone, 13, 14, 153, 164–66

P

Pacific Power and Light Co., 255
Paper pulp, 37
PCBs. *See* Polychlorinated biphenyls.
Pecos River Valley, 360
Pennsylvania, 345
Père David's deer, 65
Peregrine falcon, 56, 67
Pesticides
  Agricultural land and, 312
  Integrated pest management, 304–305
Pesticides, 8
  Water pollution and, 86, 109–111
Peyote cactus, 58
Phenol, 110
Philadelphia, 126, 153
Philippines, 10, 51
Phosphate, 331–32
Phosphorus, 112–14
Phthalate, 96
Pigeons, 62
Pinchot, Gifford, 296
Pithecophaga jeffreyi, 68
Plutonium, 290
Point Reyes National Seashore, 301
Polar bear, 66
Polybrominated biphenyls, 202, 229
Polychlorinated biphenyls, 16, 89, 110, 111, 114, 202
Population
  Age-adjusted rates for major causes of death, 1900–1978, 193
  By residence, race, and Hispanic origin, 340–41
  Estimates by states, 1979, and changes, 1970, 342–44
  Shifts, 338
  Trends, 339–45
  World growth, 500 B.C.–2000 A.D., 42
Powell, John Wesley, 351
Prairie dogs, 61
Presidential Commission on World Hunger, 7
Presidential Task Force on Global Resources and Environment, 5
Protection of the Mediterranean Sea against Pollution from Land-Based Sources, 20
Public lands. *See* Land use.
Public Rangelands Improvement Act of 1978, 297, 310
Publicker Industries, 316
Puma, 33
Puncture vine, 63

R

Rabbits, 44
Radioactive waste disposal, 18–20, 288–89
Radium-226, 186
Radon gas, 185
Rajasthan, India, 348
Rangeland Management Program, 311
Rangelands, 310–11
RARE II. *See* Roadless Area Review and Evaluation.
Raybestos, 223
Reclamation Act of 1902, 329
Red Sea, 56
Redwood trees, 47
Resource Conservation and Recovery Act of 1976, 89, 98, 191, 216–20, 395
Rhinoceros, 58
Ribbed mussels, 108
Rice, 51–52
Rio Puerco Basin, 349–51
River of No Return Wilderness, 305
Roadless Area Review and Evaluation, 305–306, 376–79
Rogovin, Mitchell, 288
Rowley, Mass., 82

S

Sacramento, 82
Safe Drinking Water Act of 1974, 86, 98, 116, 395
Sahara Desert, 347
San Joaquin Valley, 352–57
Santa Cruz River Valley, 348
Santa Rosa Ridge, 57
SCM Corp., 223
Science and Education Administration, 312, 318, 319
Sea lamprey, 46
Sea oats, 67
Sea otters, 33, 66
Sea turtle, 24
Seabrook, N.H., 381
Seagrass, 35
Securities and Exchange Commission, 392
Selenium, 89
Selway-Bitterroot Wilderness, 305
Senegal, 222
Seri Indians, 35
Shoshone pupfish, 43
Sierra Club, 301
Sierra Leone, 191, 222
Slash pine, 36
Smooth sumac, 37
Snail darter, 33, 39, 67
Snake River Birds of Prey National Conservation Area, 309
Social Security, 227
Social Security Disability Insurance Program, 225
Soil Conservation Service, 359
Soil and Water Resources Conservation Act of 1977, 313, 320
Solar Energy Conservation Act, 264
Solid Waste Management, 122–26
South African jackass, 56
South Brunswick, N.J., 82
Soviet Union, 68, 307
Sperm whale, 36
Sri Lanka, 10, 26–27
Star Lake Canal, 109
Starlings, 46
State Department, 222, 241
State governments, 99–100, 183, 326–27
State of Minnesota v. *NRC*, 381
State of North Dakota v. *Andrus*, 378
State Water Quality Reports, 109
Steelhead trout, 67
Steller's sea cow, 31
Stock Raising Homestead Act of 1916, 295
Stripers, 109
Stryckers Bay Neighborhood Center v. *Karlen*, 374–76
Suckers, 114
Sulfur, 25
Sulfur dioxide, 153
Surface Mining Control and Reclamation Act of 1977, 99, 283, 301, 330, 393, 394
Sweden, 13, 185
Switzerland, 15
Syracuse, N.Y., 153
Synthetic Fuels Corporation, 264

T

2,4,5-T, 86
Taiga, 52
Taiwan, 52
Tampa, 153
Tannin, 37
Tanzania, 37
Taxol, 37
Taylor Grazing Act, 296
Technology Assessment, Office of, 267
Tellico Dam, 39, 327
Tennessee, 109
Tennessee Valley Authority, 327
Tetrachloroethylene, 86, 92, 95

Texas, 91, 339, 345, 357
Texas Water Quality Board, 109
Thailand, 9, 10
Three Mile Island, 286–88
Tiger sharks, 48
Tomato, 34–35
Toluene, 96
Toxaphene, 86
Timber and Stone Act of 1878, 295
Toxic substances
  Birth defects data, 205
  Cancer and, 192–95
  Control strategies, 205–206
  Effects of environmental chemicals and drugs on male reproduction, from human studies, 204
  Export policy for, 240–42
  Federal laws on, 191–92
  Issues in regulation of, 214–30
  Lung disease and, 195–99
  Occupational exposures in trades employing large numbers of women, 202–203
  Reproductive effects, 199–205
  Testing of, 232–40
  Trade secrets, 230–32
  See also Hazardous wastes.
Toxic Substances Control Act, 99, 230, 232–40, 393, 395
Toxic Substance Pollution Victim Compensation Act, 229
Toxic Substances Strategy Committee, 192, 232
Trans-Alaska Pipeline, 48
Transferable Emissions Reduction Assessments, 390
Trichloroethylene, 82, 86, 90, 92, 97
1,1,1-trichloroethane, 92, 95
1,1,2-trichloroethylene, 95
Trifluorotrichloroethane, 95
Trihalomethanes, 86–87
TRIS, 240, 241
Tucson, 359
Tumbleweed, 62
Turtlegrass, 48

U

Underground Injection Control Program, 98
United Nations Environment Programme, 1, 12, 15, 20, 27, 241, 267
United States
  Beef imports, 11
  Caffeine consumption, 210–12
  Desertification, 346–60
  Diesel exhaust, 212–14
United States—Continued
  Gross energy consumption, 1900–79, 259
  Jojoba farming, 37
  Lead exposure in, 206–210
  Ocean dumping, 13–20
  Oil tanker incidents and spills, 1969–79, 21
  Ozone depletion action, 13
  Passenger car efficiency index, 1967–79, 260
  Policies on biological diversity, 69–71
  Population by residence, race, and Hispanic origin, 1979 and 1970, 340–41
  Population trends, 339–45
  Productivity in, 387
  Sport hunters and conservation, 57–58
  Tropical forest conservation, 9
United States v. *Richardson*, 382
Uranium, 290
Urban Development Action Grant Program, 383
Ureaformaldehyde, 185–86
U.S.-Canada Research Consultation Group, 25
U.S. Geological Survey, 91, 95, 100, 279, 356, 357
U.S.-Mexican Consultative Mechanism, 26
U.S. Steel, 392
U.S. Water and Power Resources Service, 329, 354
Utah, 223, 298

V

Velsicol Chemical Co., 215, 216
Veterans Administration, 223, 227
Vermont Yankee Nuclear Power Corp. v. *NRDC*, 375
Vietnam, 223
Vinyl chloride, 86, 177
Virginia, 111, 345
VM–26, 37

W

Walking catfish, 46
Washington, 255, 298, 345
Washington, D.C., 134
Water, ground
  Concentrations of selected synthetic organic compounds in raw and finished ground water, 93
  Contamination of, 81–83, 87–91
  Data on, 91

Water, ground—Continued
Depletion of, 354–55
Federal responsibility for, 97–99
New York State monitoring program, 95
Onsite domestic waste disposal systems, counties with more than 50,000 and 100,000, 90
Organic chemicals and, 85–86
Organic compounds found in ground water as reported by the states, 94
Special characteristics of, 84–85
Use, 1950–75, 84
Volume and trends, 83–84
Water hyacinth, 46, 62
Water Resources Council, 83, 327, 329, 346
Environmental Quality Evaluation Procedures, 326
Principles and Standards, 325
Water quality
Congressional action, 327–30
Costs of, 395
Estimated number of water supply systems in violation of federal drinking water standards, 1979, 119
Lake impairment, 112
Pesticide and nonpesticide-related pollution, 1978, 110
Policy implementation, 325–26
Regulatory activities by region, 1978–79, 328
Resource conservation, 324–25
State programs, 326–27
States reporting water supply systems in violation of federal drinking water standards, 1979, 121
Water, surface
Cadmium, lead, and mercury, 105–108
Conditions of, 100–108
Dissolved oxygen, 104–108
Dissolved oxygen, 1975–79, 104
Drinking water contamination, 116, 118–20
Estuaries and coastal waters, 114–16
Eutrophication, 111
Fecal coliform bacteria, 101–102
Fecal coliform bacteria, 1975–79, 102
Great Lakes, 113
Improving monitoring of, 120–22
Industrial pollution, 126–28
Lakes, 111–14
Water, surface—Continued
Nonpoint sources of pollution, 133–36
Pretreatment programs, 128–30
Solid wastes and, 122–26
Status of active shellfish harvesting areas, 1977–79, 117
Total cadmium, 1975–79, 105
Total lead, 1975–79, 106
Total mercury, 1975–79, 107
Total phosphorus, 102–103
Total phosphorus, 1975–79, 103
Toxic substances and, 109–111
Urban pollution trends, 108–111
Wax, 36
Weeks Act of 1911, 331
Weevils, 63
Welland Canal, 46
West Germany, 185
West Side Urban Renewal Area, 374
Wetlands, 327
Whales, 22–24
Whitefish, 114
White-tailed deer, 66
Whooping crane, 66, 67
Wild rice, 66
Wildebeest, 35
Wilderness, 376–79
Wilderness Act, 40
Wilderness Preservation System, 377
Wilderness review, 309–310
William O. Douglas Arctic National Wildlife Range, 300
Willow Island, W. Va., 205
Wilson, E.O., 44
Winthrop, Maine, 136–37
Wisconsin, 362
Wolves, 44
Wood's cycad, 65
World Conference on Sea Turtle Conservation, 24
World Conservation Strategy, 1, 5–7
World Meteorological Association, 12
World Wildlife Fund, 1
Wyoming, 284, 285, 298, 339

X

Xylene, 97

Y

Yellowstone National Park, 295
Yosemite National Park, 300

Z

Zaire, 610
Zea diploperennis, 32, 34

☆ U. S. GOVERNMENT PRINTING OFFICE : 1981 335-801/7090